ANIMAL LIFE OF MALAYSIA

J. FRANK DANIEL

To my friend Jos. E. Brown,
with sincere regard
Lizzie Daniel
August 27, '01.

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Orang-utan. The largest specimen ever captured: length from tip to tip of arms, 8 feet, 4 inches; weight, 150 pounds. (Field Columbian Museum. Photograph by Jas. G. Brown.)

ANIMAL LIFE

OF

MALAYSIA

BY

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MEMORY

OF

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PREFACE TO THE SECOND EDITION

Several new chapters on various types, and one complete section on mollusca, have been added to the first edition. Also a list of simple experiments has been devised, not only to lend interest but to encourage a closer observation of living things. A number of important illustrations, obtained from the Field Columbian Museum and from Frank M. Woodruff of the Academy of Sciences, Chicago, have added materially to the completeness of the book.

I wish to acknowledge the valuable suggestions given by Professor Samuel W. Williston of the University of Chicago, who read the manuscript; and to thank my former teacher, Professor George H. French, of the Southern Illinois Normal, at Carbondale, who kindly read the proof.

J. F. D.

VERTEBRATES

ANIMAL LIFE OF MALAYSIA

SECTION I

MAMMALS (CLASS MAMMALIA)

MONKEYS

Monkeys belong to the first or highest order of animal life. This order is called primates (prī′mātes), and includes man as well as monkeys.

Most monkeys make their homes in warm countries, and prefer to live in forests where there is plenty of the food that they like. They are excellent climbers and run about as safely in the trees as on the ground. They have two hands, like man and their fingers are also provided with flat nails; though they can not be trained to useful work like the human hand. On their feet they have the same number of toes as man, but in monkeys the great toe is placed at the side of the foot, making it distinctly hand-like. Because the feet correspond to the hands of man monkeys are sometimes called quạd′rụmā′nà—(*quatuor,* four, and *manus,* a hand).

The monkey family is divided into two great classes: Monkeys of the New World and those of the Old World. The monkeys of the New World generally have long tails, with which they can catch hold of a limb and swing the weight of the body as well as with their hands. In a few kinds the tail is so useful that, by means of it, the monkey can even pick up food and carry it to the mouth. Old-

World monkeys are larger and stronger than those of the New World. Some of them have long tails, but most of them have either short tails or are altogether tailless.

In Malaysia there are several kinds of monkeys, all of the Old-World type. They vary in size from the common monkey of the Philippines to the man-like gibbon common

FIG. 1. New-World monkeys

to most parts of Malaysia, and the powerful orang-utan found in Borneo and Sumatra.

Three kinds of monkeys are found in the Philippines: these are the common Philippine monkey, a monkey that is somewhat like it, and a large, almost tailless, black monkey found in Mindanao. The last two are not usually given

as Philippine monkeys since they were probably introduced from the Celebes.*

The Philippine Monkey. (A young monkey is gentle and makes a good type for study.) The common monkey of the Philippines may be found in most of the forests of the islands. They play among the trees and scold and chatter like children. If they hear a noise they scamper through the trees

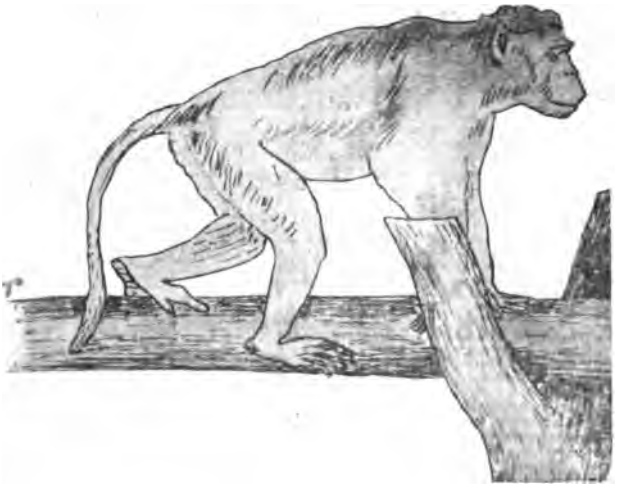


FIG. 2. The Common Monkey

to see what is making it, and if they find an intruder they try to frighten him away.

This monkey, like several of the Old-World types, has cheek pouches. These little pouches, or pockets, are between the jaw and the cheek and are used both to hold and to moisten the food while the monkey is eating. Feed a monkey a banana and note these pockets.

The tail is long, but it is nearly always carried in a

* Based on a recent list of the Edinburgh Museum.

drooping position. It is never used in grasping or picking up objects, as is the case in New-World forms.

If taken young, this monkey makes an interesting pet and can be taught many tricks. In fact, monkeys are the most human-like of all animals.

Anthropoid Apes. While the common monkey is somewhat like man, yet the closest likeness is found in the group of man-like or anthropoid (ăn'thropoid) monkeys. These monkeys are usually called apes. They have no cheek-pouches, and are generally tailless.

There are four kinds of anthropoids, the chimpanzee (chĭm-păn'zee), the gorilla (go-rĭl'lȧ) of Africa, the gibbon (gĭb'bon) and orang-utan (orăng'ụtăn) of Malaysia.

The gorilla and the chimpanzee are the largest of these. The gorilla grows to be five and one-half feet high and sometimes weighs more than two hundred pounds.

The Gibbon. Several kinds of gibbons are found in Malaysia. The largest of these is known by having a gray or whitish beard. A smaller kind is called the white-handed gibbon; and a third kind with a band of pure white across its forehead is known as the white-browed gibbon. While there are no gibbons in the Philippines proper, yet a fourth kind with dark hair and bluish face is found in the Sulu Islands between the Philippines and Borneo.

Gibbons are usually less than a meter in height, and are the smallest of the anthropoids, but they are able to stand the most nearly straight. When walking erect the gibbon often carries its arms crossed over its head. This may be

because the arms are so long that they are in the way of walking. Note the length of the arms in Fig. 4.

The arms, though long, are not so strong as in other anthropoids; but their muscles are much better developed than those of the leg. This greater development of the arms is due to the gibbon's way of traveling. Instead of using the legs,

FIG. 3. Skeleton of man

it swings its body from tree to tree by its arms. The larger anthropoids, like the gorilla and the orang-utan, have arms that are sufficiently strong to crush a man.

The hind limbs are little used since the gibbon seldom walks erect, and the muscles are small in comparison with the muscles in man's leg.

Gibbons usually live together in crowds. There are sometimes fifty or even more in a single troupe. Their cry is the morning call to the mountain people. This cry begins about daybreak; many join in the call until the forests ring for miles with the sound. After the sun is well up the gibbons become quiet and either eat or sleep the rest of the day. In the evening they call again, but their evening call is neither so loud nor so long.

FIG. 4. Skeleton of gibbon

FIG. 5. Skeleton of orang-utan

Although the head of the gibbon has much the same shape as the head of man, yet in the scale of intelligence the gibbon is the lowest of the anthropoids.

The Orang-utan. The highest form of life, except man, found in Malaysia is the orang-utan. The word orang-utan in the Malay language means wild man; (*orang,* a man, and *utan,* wild or forest). This large man-like monkey lives in the tops of the highest trees in the forests of Borneo and

Sumatra, and seldom comes to the ground. At night, however, it descends to a low tree, in the top of which it makes its bed. The bed is made of branches laid crosswise and lined with leaves. The orang-utan has the habit of going to bed early and of not getting up until the sun has dried the dew off of the trees.

The young and the old orang-utan differ greatly in habits. The young one is gentle and affectionate, but the old one becomes cross and dangerous. The expression of the little orang is very child-like. If it is given food that is sour it makes very ugly faces, but, if it has food that it likes, it munches it contentedly.

The mother orang is not so large nor so fierce as the male. In fact, she is very tender with her little one while it is young. When it gets older, however, if it is not good she boxes its ears and sends it away howling.

There is a story told of a young orang that had two kittens for friends. It usually carried them around under its arms. Sometimes in their play the kittens would climb upon its head and then slide off. This was not much fun for the young orang, however, for their sharp claws dug into its skin and gave it great pain. At last they hurt so badly that it picked the kittens up and examined their feet carefully. Upon discovering the claws it tried to pull them out, but when it found that impossible it let the kittens go on with their fun rather than lose their company.*

* In Darwin's *Descent of Man* a similar story is told of an old mother baboon who upon losing her little one adopted a kitten. Upon being scratched by the kitten, she picked it up and finding the claws, bit them off.

In structure also, the young is more human-like than the aged male. When young the skin is smooth and soft, but in the old there are huge rolls of fat at the sides of the neck, the skin is wrinkled, and the body is covered with long, reddish-brown or black, shaggy hair. As the young gets older the body grows more and more out of proportion. The arms become long; the knees bend out and the legs get so crooked

FIG. 6. Young orang-utan (After Jordon and Heath)

that the soles of its feet turn inward when it tries to walk. Mr. Wallace * tells us of an orang-utan that was only four feet two inches in height, that had a waist measure of forty-three and a half inches, and a stretch from tip to tip of arms of seven feet nine inches. (See the orang-utan in the frontispiece.)

The orang-utan has two sets of teeth. The first is called milk teeth, and the second set permanent teeth. How many sets has man? The milk teeth are crowded out by the per-

* Wallace's *Malay Archipelago,* p. 47.

manent set. The teeth are the same in kind and number as are found in man, but the long, pointed teeth, called the canines (kā'-nine) become longer and more dangerous as the orang-utan grows older.

The brain of an orang resembles the brain of man, but it is greatly inferior in size, and does not overhang the eyes. While the orang-utan possesses a great deal of intelligence compared with lower animals, yet it has not the power of reason, and so is not capable of much education. A naturalist tells us that if a fire is built in the forest, on a cool night, monkeys will come to it to warm themselves; but if the fire should burn low they would never think of putting on more wood in order to keep warm. The lowest savage, however, knows how to make a fire to protect himself from the cold, thus showing his greater intelligence.

Many animals have a kind of language or a way of expressing themselves. The cat purrs when it is contented. A dog growls when it is angry. When a hen sees a hawk she warns her little chicks by a sharp cry and they quickly run and hide. When the danger is over she clucks to them and they come running out again. The chatter of monkeys is probably a higher form of expression, but it can not be called a true language. It can never be developed like the human language, because even the highest anthropoid has few ideas to express.

Life History. The mother monkey seldom has more than one little one at a time. When very young it is helpless, like a baby. In a short time, however, the young of the common monkey is able to take care of itself. This is not

the case though with the young gibbon or the orang-utan. These cling tightly to the mother's fur and are carried around with her for several months until they gradually become stronger. They then begin life for themselves, but it is only after several years that they grow to be as large as their parents.

NOTE-BOOK *

Give two differences between Old- and New-World monkeys.

Draw the common monkey. To which group does it belong?

Compare the hands and feet of a monkey with the hands and feet of man.

Name the anthropoid apes and tell the home of each. Which one is the largest? Which the smallest?

Name three ways in which the gibbon is more like men than is the Philippine monkey. In what respects is it lower than the orang-utan?

Which walks better erect, the orang-utan or the gibbon?

To what islands is the orang-utan confined?

Describe its home and bed.

* The excellent results obtained from Philippine students in making note-books suggested to the author the importance of adding after each chapter a list of questions for this purpose. It is intended that only the answers be written in the note-book. The drawings suggested may be used as frontispieces to each chapter.

In case note-books are not at hand good ones may be made from the paper issued by the Department. Each sheet should be folded once, and when the drawings have been made and the answers to the questions neatly written in, page by page should be stitched to a suitable cover.

A little experimenting on the part of the teacher will insure to the class a neat and uniform note-book.

Tell something of the disposition of the young orang-utan.

How do its teeth differ from those of the aged male?

Make a list of the ways in which an orang is like man; unlike him—in shape of body, in limbs, in head.

Notice the general shape of the backbone in man and in the orang-utan. Which has two curves? A double curve gives grace in walking. (See Figs. 3 and 5).

CATS

The cat family has many representatives; among them are the lion, the tiger, the leopard, the wildcat, and the common house cat. All of them are four-footed and so are called quadrupeds (quạd′rụ-pĕds). They are flesh eaters and are, therefore, called carnivora (kärnĭv′orȧ). With the exception of the house cat, which has been domesticated, they are the fiercest of animals. They usually live alone in jungles. They sleep in the daytime and roam the forest at night in search of food.

The House Cat. The house cat, the wildcat, and the tiger are found in Malaysia. The Malaysian house cat, which is common in the Philippines, has a short scrubby tail and is not so large nor so beautiful as the European house cat. The body is covered with a coat of fur of various colors. Like all other cats, the Philippine house cat is very active and is almost noiseless in its movements. Its legs, although slender, are well provided with strong muscles. Under each foot you will notice several little pad-like cushions. What do you suppose is their use?

The front and the hind feet have five toes each. One of the hind toes, however, is on the inside of the leg. Each toe has a sharp curved claw. The claws are drawn back while the cat is walking. This is why a cat's track in the mud does not show prints of the claws as a dog's does.

The cat's eye is well adapted for seeing at night. Since there is very little light at night the pupil of a night-seeing animal must be able to open very wide to let in all the light possible. In some of the cats the pupil is slit-shaped as in

FIG. 8. Claws of Carnivora: (A) Drawn back; (B) Extended

the house cat; in others it is round, but in all it is capable of opening very wide.*

The Philippine Wildcat. One of the smallest of the wildcats is found in the Philippines.

It is not quite so large as the Malaysian house cat, and, like it, has a rather short tail and long legs. Its body underneath is a clear white; above it is a beautiful yellow dotted with round black spots, somewhat like those of a leopard. Because of this it is sometimes called the "leopard cat." This cat lives in the mountain regions of Negros, Panay and

* EXPERIMENT NO. 1.
Remain in a dark room for some time and note the size of the pupil of your eye; then note the same after staying in a bright light for a while.
Explain both cases in the note-book.

Cebu, and eats birds and other small animals. It usually has from three to four kittens at a time. In captivity it lies curled up in its cage and is not restless, like most other cats, yet it is extremely spiteful and hard to tame.

FIG. 9. Philippine wildcat (Jesuit Museum, Manila)

Tigers. Tigers are not found in the Philippines or in the large island of Borneo, but they are plentiful in Java and Sumatra. The tiger is the largest and the most beautiful of the Malaysian cats, and one of the largest and strongest of the cat family.

The body of the tiger is sometimes more than three and a half feet high and nearly seven feet from tip of nose to root of tail. It is graceful in form and of a striking color, yellow above and white below, with black stripes running

partly around the body. How does this differ in marking from the Philippine wildcat?

The tiger is as powerful as it is graceful. Even the lion is but little, if any stronger. It is also very stealthy and moves so quietly that it often creeps upon and catches the wildest of animals. Under the foot the pad-like cushions are well developed. These pads make the animal almost noise-

FIG. 10. Tigers (Photograph by Frank M. Woodruff)

less in its movements. Other animals are afraid of the tiger and flee at sight of it. If nature had not made its feet for creeping silently upon its prey the tiger would often suffer from hunger.

The claws are also of great use to it in procuring food. They grow to be two or three inches long and are very strong and sharp. These claws are drawn up and protected while not in use. If they were not protected in this way they would soon wear dull and become useless.

The tiger's head is shaped like the head of the house cat,

but it is many times larger. Note the shape of the pupil, Fig. 10.

Most wild animals have a keen sense of smell. The tiger is able to locate another animal a long distance off by its sense of smell. At the sides of the nose are long hairs called whiskers. These are used as feelers or organs of touch.

The mouth is set with powerful teeth. The four longest are called canine (kā'nīne), or tearing teeth. Flesh-eating, or carnivorous animals could not tear their food to pieces without these long pointed teeth.

The Lair. The tiger's home is called a lair. It is made in the jungle where the thick bushes and the high grass hide it. At nightfall the tiger comes out of its dark home to search for food. It often seeks some body of water where deer or other animals come to drink. It hides in a dark spot and, when the deer is ready to drink, springs upon it as a cat would spring upon a mouse. A large tiger is so powerful that it can kill and carry off a deer or even a half-grown cow.

When tigers are very hungry and can not catch wild animals, they will seize children and even grown men. In Java as many as one hundred and forty-eight people have been killed by tigers in a single year. The people are so much afraid of them that when one enters a town they flee in terror.

In India, where these animals are very numerous, men go tiger-hunting. They ride on elephants, for both horses and camels are of little use in this sport. The sight of a tiger makes them tremble with fear. But elephants are not so

much afraid, for their great size and strength protect them. When a tiger has been found and surrounded it sometimes springs upon an elephant, but before it can do any harm the men kill it with spears or guns.

Another way of destroying the tiger is to dig a deep pit

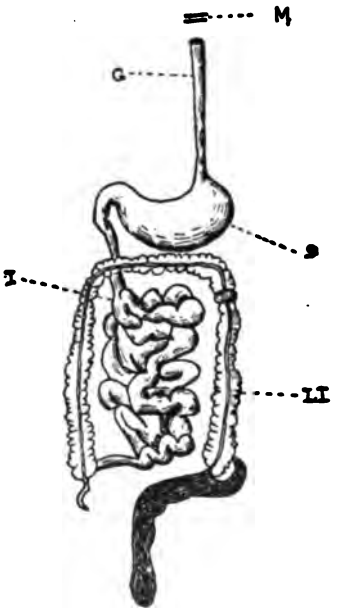


FIG. 12. Digestive tract of a mammal: (G) gullet, or esophagus; (I) intestine; (LI) large intestine; (M) mouth; (S) stomach

in the ground, wider at the bottom than at the top. The hole is carefully covered over with leaves. Meat is put into it, and the tiger, attracted by the smell, falls into the trap.

Life History. Two or three little tigers are born at one time. At first, they are only about half as large as a large

house cat, and, indeed, are much like large kittens. They are called cubs. The mother tiger has to hide her little ones away, for they have many enemies. Even the male tiger would kill them if he came across them. When the cubs become older they learn to take care of themselves, and in two years they are as powerful as their parents.

Digestion. It is important now that we should know what becomes of the food that is eaten by animals. Food that is taken into the mouth, is chewed fine by the back teeth, and then passes down the gullet, or esophagus (ē sŏf'a gŭs), into the stomach. The stomach changes it into a half-fluid-like mass. It then goes into the long intestine (in tĕs'tĭne), where it is mixed with other digestive fluids. Here its digestion is completed and it is made suitable to be absorbed by the blood-vessels in the walls of the intestine and taken into the blood current, by which, as we shall see later, it is carried to all parts of the body.

NOTE-BOOK

Name some members of the cat family.

Give examples of and explain the difference between quadrupeds and quadrumana.

Why are cats called carnivora? Name some other carnivorous animals not of the cat family.

Name and compare the Philippine cats.

What becomes of a cat's claws when it is walking?

How are the claws sharpened?

Why is the pupil of a cat's eye so large at night?

What are the long hairs at the sides of the nose used for?

Which Malaysian cat is the largest? Where is it found?

Why does the tiger need pads under its feet?

How does the eye of the tiger differ from that of the house cat? Draw its head.

What kind of teeth does a flesh-eating animal need?

Describe two ways in which a tiger catches its food.

Why are these animals hunted?

Give a short description of a tiger-hunt.

Trace the digestion in a mammal, Fig. 12.

DEER

The deer of Malaysia are generally smaller than those of other parts of the world. Some of those of Sumatra and Borneo are larger than the Philippine deer, but all are nearly alike in color and form.

In the Philippines, deer are found principally in the mountains of Luzon, Negros, Leyte, and Samar. They grow to be about three feet high, and are very slender and graceful. They are gray or reddish-brown in color, and the young deer, or fawn, as it is called, is beautifully marked with white or yellow spots. (Fig. 14).

The deer has a graceful head. The eye is clear and gentle. Under the eyes are two little pockets called tear-pits. These are not made to hold tears but they secrete a kind of fluid. In the males, the head is provided with branching horns, called antlers. These are not hollow like the horns of the carabao, but are formed of a solid bone-like substance. The antlers are shed once a year and grow out again within

two or three months. Each year the new antlers have an additional prong until the animal is several years old.

The feet of the deer are different from the feet of any other animal that we have studied. The two toes of each

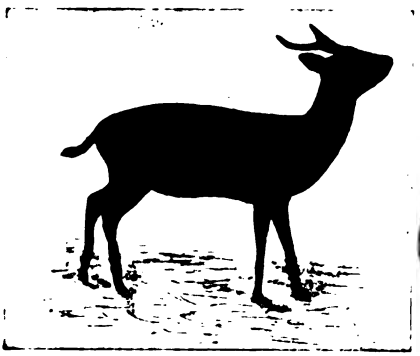


FIG. 13. Philippine deer (Jesuit Museum, Manila)

FIG. 14. Philippine fawn (Cebu High School. Photograph by Jas. G. Brown)

foot have a hard covering around them called a hoof. Above and back of the hoofs are two small, or "false hoofs." Name some other hoofed animals. Do you know an animal that has an odd number of hoofs on each foot?

Usually the deer can escape its enemies by running, since it is provided with long, slender legs and sure feet; but if it is not able to escape by running, it uses its antlers and even its feet for protection. When an enemy is close at hand, the deer rushes upon him, and with its knees stiff and its fore-feet close together, strikes him with its sharp hoofs, making a dangerous wound.

All animals that have hoofs eat grass, and all animals that eat grass are called herbivora (hĕrbĭv′orā). Thus we see that the deer is herbivorous.

Herbivorous animals may be divided into two classes: odd-hoofed forms like the horse, and even-hoofed animals like the cow. Even-hoofed animals may again be divided into ruminants (ru'mi nants), or cud-chewers, and non-ruminants.

We may take the goat or the sheep as a type of a ruminant. If you watch it while it is lying down you will see that it continues chewing, although it takes no new food into the mouth. We say that the animal is "chewing its cud." All animals

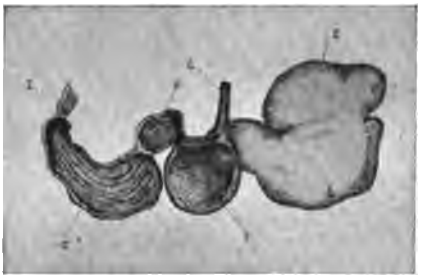


FIG 15. Compound stomach: (C) second stomach; (D) third stomach; (E) true stomach; (G) gullet; (I) intestine; (P) paunch

that chew the cud are called ruminants. Name as many ruminants as you can.

Both the teeth and the stomach of a ruminant, or cud-chewer, are made especially for eating grass. In the deer there are no tearing teeth like those found in the tiger. In the front of the lower jaw are wide, sharp, cutting teeth, but above them, in the upper jaw, the deer has no teeth. Instead there is a hard plate. Has the carabao upper front teeth?

Grass is hard to digest, and so the stomach and intestines of a ruminant are fitted for its digestion. The intestine is

unusually long, that of the sheep, for example, being about twenty times as long as the body. The stomach is compound, that is, it is divided into rooms, or parts, Fig. 15. The grass, after being swallowed, collects in the first large stomach, or paunch (p.) When the animal lies down to rest, the grass goes into the second stomach and is then sent back to the mouth again in little cuds or pats, to be chewed finer. It then passes into the third room where it is moistened with other fluids. From the third stomach it enters the fourth, or true stomach, before being sent into the long intestine to be further digested and finally absorbed into the blood. Compare the digestion in a ruminant with that of the tiger. (See page 16).

The Mouse Deer. The smallest of ruminants, and one of the most beautiful, is the little mouse deer found in Balabac, near Palawan. This pretty little animal is only about eight or ten inches high. It is a reddish brown color, marked with a few clear white stripes under the neck. The head is a little larger than a cat's and is very gracefully shaped. The ear is small, but the eye is large and dark. Like the common deer, it has no cutting teeth in the upper jaw, but unlike them the male of the mouse deer has two long upper canine teeth or tusks that curve downward, extending below the lower jaw.

This deer never has horns or antlers, but depends wholly upon its slender legs to escape its enemies. In walking it steps very cautiously as if afraid to put its foot down; but if frightened it leaps away in quick, stiff-kneed jumps. It can not run very far, however, for it soon tires. People

used to think that it had no joints in its legs, for both in walking and running it acts as if it were stiff-kneed. This was a mistaken notion, however, for when it lies down it bends its legs under its body.

Some of these little animals are kept in the park at Manila. They have a little house built for them, but they are

FIG. 16. Mouse deer, or chevrotain (Jesuit Museum, Manila)

so shy that they seldom come out during the day. In their wild state, they rest in the warmer part of the day concealed in the grass or among rocks, and come out only in the evening and morning for food.

This little cud-chewer has a compound stomach like other ruminants, but instead of four divisions, or rooms, its stomach has only three.

This family of deer is widely separated. Some of its relatives live in far away Africa. One species lives in India; two in Java and Sumatra; and this one by some way or other has come to live on the small island of Balabac. Here, protected by the tall grass and thickets, the tiny mother raises

her young. About the close of the rainy season, one little one is born, or sometimes two. For several months it is cared for and protected by the tiny mother until it has learned to shift for itself.

Some of the young are caught and tamed. They get along very well in captivity, and make interesting pets. Two of these little creatures were once sent from Java as a present to the queen of England. They could not live very long, however, in so cold a climate.

NOTE-BOOK

Compare Philippine deer in color and size with those of other parts of the world.

How does the color of the fawn differ from that of the old deer?

Draw the head, lettering the antlers (a), the eye (b), and tear-pit (c).

Name three ways in which the antlers are unlike the horns of the carabao.

What is the use of a hoof? In what respect is it like a claw?

Tell three ways that the deer has of escaping its enemies.

Compare the food of a hoofed animal with that of the cat.

What characteristic of hoofed animals separates them into two groups?

Animals that have an even number of hoofs may be divided into what two divisions?

Give an example of three general types of hoofed animals.

Are odd-hoofed forms ever ruminants?

Describe the teeth of a cud-chewer.

Draw a compound stomach. Why is it thus modified?

What is the use of the paunch, or first stomach?

Trace the food, eaten by a ruminant, in its digestion.

Draw the smallest of ruminants. How is it different from other deer in size, in the shape of its head, in its digestion?

Where is it found?

Describe its habits?

Write a short sketch of its life history.

BUFFALOES

The Carabao. Another herbivorous animal is the buffalo (bŭf'fa-lō). The carabao, or water buffalo, is a form well known to all of us. It is not native to the Philippines, but is found all over Malaysia and southern China. Wild ones are found in some of the mountains here, but their ancestors probably escaped from captivity, and they have been left alone so long that they have become wild.

The body of the carabao is much larger than the body of a cow, and its heavy legs are provided with more powerful muscles. How many toes has the carabao? Have you ever seen it chewing the cud?

The horns are heavy and curved backward over the neck. They have a bony center or core, and are not shed, like the antlers of the deer.

The skin is of a blue-gray color and is covered with thin, dark, or reddish-brown hair. The skin needs a great deal of water, and it is the habit of this animal to lie down in water or mud for hours, with only its nose out.

Carabaos are excellent friends with a kind of big white bird, called the heron. (See Fig. 45.) You may sometimes see a heron taking a nap on the back of a carabao, while the carabao is peacefully eating grass. Why do you suppose they are such good friends?

Much has been said of the strength of carabaos, and of how useful they are when domesticated. Their immense strength

FIG. 17. The carabao

adapts them to pulling heavy loads over the worst of roads. But they tire quickly and must have frequent baths. They are used in cultivating rice and corn, and, in some islands, for drawing the *quilez*. The milk is white and thick and serves as a substitute for cow's milk. The flesh of the young carabao is, by some, considered good food.

Timarao. The timarao is a kind of wild buffalo found in the mountains of Mindoro. It is much smaller than the carabao, but it has the same color and appearance, and the same

habits. Its eye is fierce and it is an enemy to be dreaded in the mountains.

The Sapi Utan. A very peculiar animal is the sapi utan of the Celebes. It is a kind of buffalo, but it does not differ in appearance very greatly from an ox. In fact, its name means "wild ox." It is little like the Philippine buffalo. The hair is a dark brown, and at the side of each jaw there

FIG. 18. Head of timarao (Field Columbian Museum. Photograph by Jas. G. Brown)

FIG. 19. Head of sapi utan

are two characteristic white spots. Under the neck the skin hangs far down and forms what is called a dewlap. The horns are almost straight and extend back over the neck. At the base they are surrounded by rings, and at the ends they are sharp-pointed.

NOTE-BOOK

Name two members of the buffalo family found in Malaysia.

Where is the carabao found?

How can we account for wild buffaloes being found in some of the mountains of the Philippines?

Compare the carabao in size and strength with the ox.

How is the hair of this animal unlike that of the horse?

Why do you think that the carabao is fond of lying in the water?

Has it an even or an odd number of hoofs on each foot? Has it any "false hoofs?"

Draw the head.

With which teeth does it cut the grass off? With which does it grind it?

Tell some kinds of work that a carabao can do better than a horse.

In how many ways is the timarao like the water buffalo?

Compare the sapi utan with the timarao.

WILD HOGS

The wild hog is far from a beautiful or a graceful animal. Its head is pointed, the body is long and bony, and the belly often almost drags the ground.

Tame hogs originated from the wild hog. The domestic pig of the Philippines is but little different in structure from its ancestors, but the European pig, Fig. 21, shows a much higher development.

The body of the wild hog is covered with stiff reddish-brown or black hairs. On the neck and back the hairs are longer and stiffer and are called bristles. What are bristles used for?

The hog has the greatest number of teeth of any animal that we have studied. There are forty-four in all. The four long canine teeth, or tusks—two above and two below—grow out-

ward and upward, the two lower being the longer and more curved.

The tusks grow constantly and usually wear off against each other. Whenever an upper tusk gets broken off, however, the lower one grows past it and if its point touches the skull, it may grow through into the brain and cause death. These tusks serve as terrible organs of defense. It means almost certain death for a dog to venture too near an angry boar.

Wild hogs have long, strong noses, or snouts. At the end

FIG. 20. Wild boar (Jesuit Museum, Manila)

FIG. 21. Domestic hog

of the snout is a pad of cartilage (kär'ti-lage). This serves as a plow to turn up the soil in search of seeds and insects. Does the hog eat grass?

From the foot of the pig why would you think it a ruminant, or cud-chewer? It is a non-ruminant, however, with an even number of hoofed toes, four on each foot. We might say that the pig is intermediate between the ruminant and the non-ruminant. It has an even number of toes, like the former, but it has a simple stomach, like the latter, and so could not be a cud-chewer.

Distribution. In the Philippines, wild hogs are found in

several of the provinces of Luzon, and also in Mindoro and Mindanao. The male hog, or boar, lives by itself in the woods. Sometimes two boars meet and declare war upon each other. Then a fierce battle begins that may end in the death of both.

Hogs like to wallow in the mud and hunters often find them asleep in mud-holes during the heat of the day. Because they are so very destructive to the fields of corn and grain, farmers are glad to have these troublesome grunters killed.

Life History. The sow, or female, has from four to ten

FIG. 22. Young boar (Cambridge Natural History)

FIG. 23. Skull of babirusa (Jesuit Museum, Manila)

little ones at a time. It is necessary for the mother to hide them from the male. What other animal does this? Until the young boar is about six months old it is striped. (See Fig. 22). The pigs stay with the mother for a year or two. Sometimes a drove of wild hogs includes two or three litters of the pigs. Boars are said to live for twenty years.

The Babirusa. The babirusa (ba′bĭrū′sȧ) is a strange, pig-like animal found in the Celebes. In Malay, the word babirusa means "hog deer." In shape it is something like a pig,

but its legs are long, and its upper teeth, or tusks, are curved upward, like the horns of some kinds of deer.

The upper tusks do not grow from the edge of the jaw, as in the common boar, but they grow through the solid bone of the upper jaw, so that the upper and the lower tusks never touch each other. By the time the babirusa is old these have curved upward over the eye eight or ten inches in length. In the female, however, the tusks remain short or are entirely wanting.

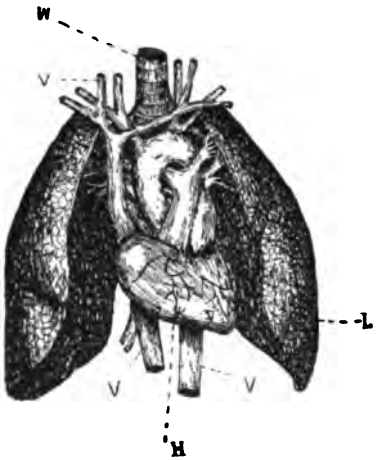


FIG. 24. Lungs and heart of a mammal: (H) heart; (L) lung; (V) blood-vessels; (W) wind-pipe

Tusks are probably of little use to the animal, for they are curved in such a way as to be of little help in fighting, and they can be of no use in eating, since the babirusa lives on fruit and is said not to root in the ground.

Babirusas live together in herds, as common hogs do, and like them they make a grunting sound; but as we have seen, the two are very different in some other respects. Two more

differences may be added. The babirusa has fewer teeth (thirty-four in all), and its young are not striped.

Rĕ'spirā'tion or Breathing. If you watch hogs rooting under the water you will see that they raise their snouts out of the water to breathe. All land animals and a few that live in the sea, such as whales (whāles) and porpoises (pôr'pŭsses), breathe air. They breathe by means of lungs. The air enters through the nostrils or the mouth, and passes down the wind-pipe, Fig. 24 (w). Two branches of the wind-pipe, called the bronchial tubes (brŏn'kial tūbes), then carry it to the air-sacs of the lungs, which are lined with many tiny blood-vessels. In the air-sacs two important things occur. First, oxygen (ŏx'ŷĝen) taken into the lungs with the air passes through the thin blood vessels into the blood. Second, impurities in the blood come out through the walls of the vessels into the air of the lungs to be thrown out in breathing. When the blood takes in oxygen and gives up its impurities it becomes a bright red color, and is called pure blood. We shall learn, when we study the circulation of the blood, what the blood does with the oxygen inhaled by the lungs.*

* Experiment No. 2.†

(a). Make a drawing of the lungs, lettering the wind-pipe (a), the bronchial tubes (b), and the lungs (c).

(b). Place the end of a large glass tube, or a piece of bamboo into the wind-pipe, tie it fast, and then blow the lungs full of air. What happens when the mouth is taken away from the tube? What causes this?

(c). After squeezing all the air out that you can, put the lungs in water. Do they sink or do they still contain sufficient air in the air-sacs to make them float?

Write a complete account of all experiments in the note-book.

† The lungs of a pig or a sheep may be obtained from the market. They should be washed very clean and kept moist so as to show the tiny vessels in them.

NOTE-BOOK

In what parts of the Philippine archipelago are wild hogs found?

How is the Philippine pig like the wild hog?

In what way do the tusks of the wild boar differ from those of the babirusa?

Compare the stomach of the hog with that of the ruminant.

In what respect are the hog and the carabao alike?

Why is the wild hog a nuisance to farmers?

How does the life history of the babirusa differ from that of the common pig?

Explain fully how a land animal breathes. What is the use of respiration, or breathing?

FIG. 25. Indian rhinoceros

THE RHINOCEROS

One of the most remarkable animals of Malaysia is the rhinoceros (rhī nŏç'e rŏs). Its skin is almost hairless and is very tough and hard. In some kinds it is thickened on the shoulders and thighs into plate-like shields. Growing upon the

nose is a horn, or sometimes two horns. The horn is solid and dark in color. In some species it grows to be nearly two feet long. The horn is thought to be used as a means of defense.

The head of a rhinoceros is somewhat like a wild hog's in shape. The eye is very small and shows a low degree of intelligence. The upper lip is longer than the lower and looks like a snout. It is used in getting food, but the rhinoceros does not root in the ground for its food. It eats grass, tender shoots, and herbs.

Each foot has three hoofed toes.

The body is very big and clumsy, in size nearly equal to the elephant's. The legs are short and the huge body nearly touches the ground.

The rhinoceros is fond of wallowing in the water and mud like the wild hog. Name another Philippine animal that has the same habit.

This animal lives in Africa, India, and Malaysia. The Indian rhinoceros grows to be nearly six feet high and ten feet long. The Malaysian form is about two-thirds as large. Both the one-horned and the two-horned species are found in Malaysia.

In the western part of Java the one-horned rhinoceros is common, being found in both lowlands and highlands. It is about four and a half feet high and seven feet long. The horn is often more than a foot in length.

The rhinoceros of Sumatra is a little smaller than that of Java. It is more thickly covered with hair and has two horns, the second or shorter horn growing behind the first.

When the rhinoceros is trying to escape an enemy it runs in a peculiar kind of trot with its head down almost to the ground. It looks awkward, but it can run fast. When it is injured, however, it rushes at its enemy fiercely and unless the hunter can get away quickly he is in danger of being run down and killed.

Bones of the Feet. It is of interest now to notice more

FIG. 26. Head of two-horned African rhinoceros

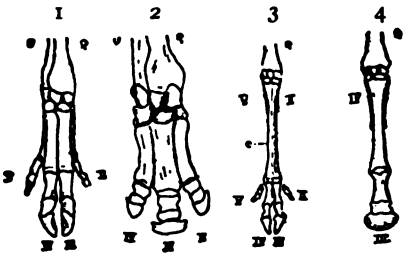


FIG. 27. Bones of feet: (1) pig; (2) rhinoceros; (3) deer; (4) horse. I to V, first to fifth toes; (U) Ulna and (R) Radius, bones of fore leg

closely the foot of some of the even-and-odd-hoofed animals that we have studied. It will be noted that none of them has the full number of toes present.

The pig, Fig. 27 (1), has the largest number, four, only the fifth being lacking. In the foot of the deer you will see that in addition to a complete loss of the first, both the second and the fifth have become rudimentary. You will further notice that the bone marked (C) is composed of two bones in the pig, but that in the ruminant (3) the two have grown together.

In which forms have the ulnar (ŭl'nar) bones of the leg (U) disappeared?

In the odd-hoofed animals the third toe is always strongly

developed, for it is this one on which much, or all, of the weight of the body is borne.

In the rhinoceros the second and the fourth toes are also well developed; the first and fifth are wanting. In the horse we note the greatest reduction found in any mammal, the third toe being the only one that is functional; even the second and fourth are either entirely wanting or are represented by rudiments as in Fig. 27 (4).

We shall next study a form, the elephant, in which the full number of toes (five) is present.

NOTE-BOOK

Name a Philippine animal that has a skin something like that of the rhinoceros. What is the principal difference?

Tell about the horn and its use.

In what way is the head of the rhinoceros like that of the hog? How is it different?

From its number of toes can you tell whether its stomach is like that of the hog or that of the deer?

How does the Malaysian rhinoceros compare with those of other parts of the world?

In what ways does the rhinoceros defend itself?

THE ELEPHANT

The elephant (ĕl'efant) is the largest of quadrupeds, although not the largest of animals. It is so tall that when men want to ride it, they make it lie down and then they climb up a short ladder to its back.

Its body is like the carabao's in color; its skin is thick like

the skin of the rhinoceros and is almost hairless. Its legs are larger around than the body of an ordinary ten-year-old boy. Each foot has five toes and makes an almost round track.

The head is massive but the eyes are small. The ears are sometimes two feet broad and are shaped somewhat like the leaf of the gabi plant. They are used by the elephant as fans to keep away troublesome flies.

The elephant's nose is four or five feet long and is called a trunk, or proboscis. It is hollow, and at the end are the two nostrils. The trunk is useful in many ways. When the elephant is thirsty it sucks the trunk full of water, then raises it straight up and lets the water run down its big throat. With its trunk it can roll up a bunch of grass and carry it to its mouth. The animal can also carry heavy logs by resting them on its tusks and holding them with its trunk. At the end of the proboscis, or trunk, there is a kind of finger with which the elephant can pick up objects even as small as a peanut.

The male elephant has two long teeth, called tusks, extending from the upper jaw, one on each side of the trunk. The tusks are ivory. It is from them that we get the ivory of commerce. Name some things made from ivory. The tusks often grow to be two or three feet long, and are used as organs of defense.

The food of the elephant is grass, hay, or rice. An Indian elephant was known to eat two hundred pounds of rice, and some hay and grass, in a single day.

Elephants are found only in the Old World. In Borneo and Sumatra they are smaller than in Africa or India. The Malaysian elephants are closely related to those of India.

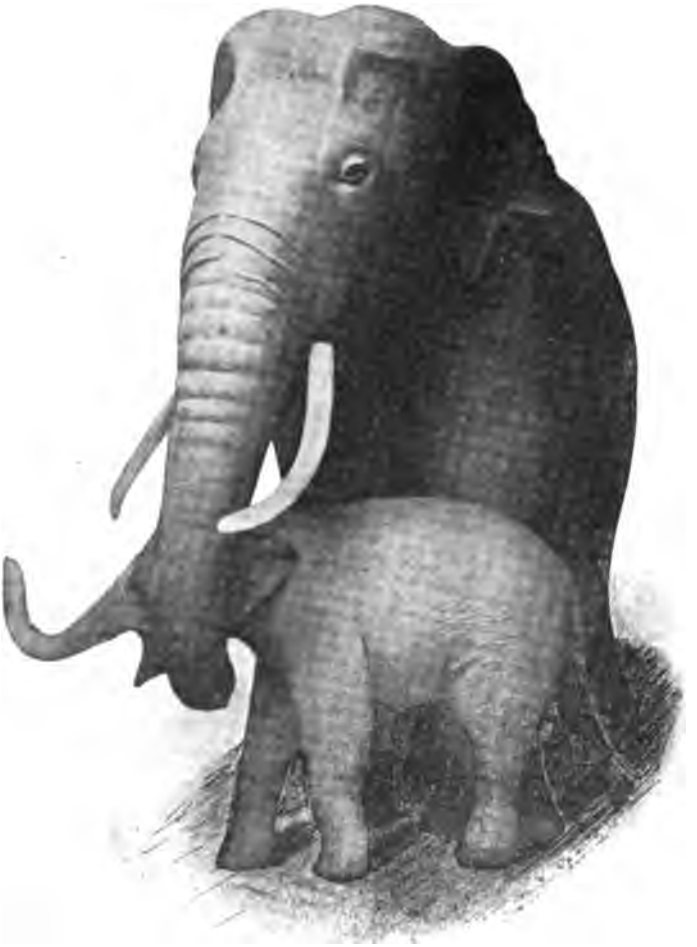


FIG. 28. Elephants — Male and young — (Field Columbian Museum. Photograph by Brown)

Elephants captured young can be tamed and taught to hunt or to work. They are so strong that they are useful to man in many ways. In India they are used for traveling. A covered saddle, or howdah, that looks like a little house, is placed on the elephant's back. It is large enough for several persons to ride in at once. The driver, or keeper, usually sits on the animal's head, between its ears, to guide it. When it is necessary to cross a river deep enough to go over the elephant's back, it holds its trunk up above the surface of the water. When the elephant is not carrying people from place to place, it works at plowing or at carrying and piling heavy logs.

Life History. Both the rhinoceros and the elephant have only one young one at a time. The baby elephant is about one meter high and strong enough from the first to follow its mother around. It is suckled for two years and is nearly twenty-five years in reaching full growth. The elephant often lives to be a hundred and fifty years old.

NOTE-BOOK

What is the largest of land animals? Do you know a sea animal that is larger?

Name three or four animals that are alike in having thin hair and a thick skin.

Describe the elephant's food and how it eats.

Tell some of the uses of the trunk.

Why are the tusks of this animal so valuable?

Why do you suppose the Malaysian elephant is more closely related to the Indian elephant than to the African?

Name some of the uses to which tame elephants are put.

Draw the baby elephant.
Write its life history.

SUMMARY OF HOOFED ANIMALS

Hoofed animals (Herbivorous).

I. Non-ruminants (stomach simple).
   1. With an odd number of hoofs:
      Examples, horse (1), rhinoceros (3).
   2. With an even number of hoofs:
      Example, only the pigs.

II. Ruminants (stomach compound).
   With an even number of hoofs:
      Examples, cow (4), some deer (only 2).

THE SQUIRREL

Material needed: If some of the pupils can bring a rat or mouse alive in a cage its teeth and way of eating can be seen.

Squirrels (skwĭr′rels) are found in most parts of the world, but are rare in the Philippines. Two kinds are found in Mindanao, and one in Samar.

The body of this little animal is usually eight or ten inches long, and is covered with a soft, thick fur of a gray or brown color. Some of the Borneo squirrels are beautifully striped with gray or reddish-brown.

Like monkeys, squirrels live in the forest and are very lively in the mornings and evenings. They sometimes go to the tops of high trees, seat themselves on a limb, and amuse themselves

by barking a short little bark. At midday, however, they take a siesta.

The squirrel has four toes on each foot. Each toe is provided with a claw, especially adapted for climbing. Squirrels can run along the ground, or jump from tree to tree, with equal ease. They often jump from a tree to the ground and scamper off without the slightest injury.

The tail is long and busy and arches over the back. It is

FIG. 29. The Gray Squirrel

FIG. 30. The Philippine Squirrel

constantly moving in short little jerks. When the squirrel jumps a long distance, the tail flattens out and is of great help in giving balance.

Squirrels have bright, inquisitive eyes. The nose is pointed, and at the sides there are whiskers that are used as feelers.

The mouth is provided with sharp teeth that are very different from the cat's teeth. In front there are two flat cutting teeth above, and two below. Fig. 31. These teeth are

not like ours, for as fast as they wear off they grow out again. In the back part of the mouth are the molars (mō'lars) for grinding the food. There are no canine, or tearing teeth, such as the flesh-eaters have. The four front teeth are fitted for cutting and gnawing, and are so sharp that a squirrel can gnaw through into a nut. The squirrel is therefore called a rodent (rō'dent) or a gnawing (naw'ing) animal. Do you know any other animal that can gnaw through wood? Name an animal that has no upper cutting teeth.

The food of the squirrel is principally nuts and seeds. He will take the hardest nut in his fore paws, holding it to his mouth while he sits upon his hind feet, and soon he has cut through into the kernel.

In cold countries the squirrel is very industrious, and shows a remarkable instinct. In the fall, when nuts are ripe, he gathers them and takes them home in his cheek pouches to store away for the winter. He sometimes puts away thousands of them, and when the snow comes and covers up the nuts on the ground, the squirrel lives happily in his hollow tree, with plenty of food to keep him from hunger until the spring comes.

Life History. The male and female of some kinds of squirrels live together throughout life. The mother builds a nest, almost round in shape, of twigs and leaves. It is built inside of a hollow tree or in the fork of a tree, and is large enough to hold the father, mother and from three to five young. If the nest is disturbed, the mother takes the little ones by the back of the neck with her teeth and moves them, one by one, to another nest. Did you ever see a cat moving her kittens?

The little ones at first have no covering of fur. Soon they are large enough to go out in the early morning with their mother for exercise. After a few months they are old enough to begin life for themselves.

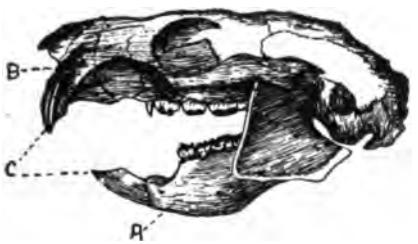


FIG. 31. Skull of rodent: (A) lower jaw; (B) upper jaw; (C) cutting teeth

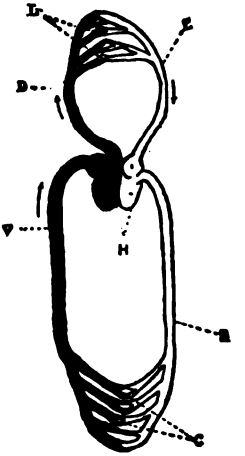


FIG. 32. Circulation: (H) heart with its four rooms, 1 and 2 on right side, 3 and 4 on left side; (V) impure blood returning from body to heart; (D) impure blood going from heart to lungs; (E) pure blood going from lungs to heart; (A) pure blood, from heart to all parts of body; (C) capillaries in body; (L) capillaries in lungs (Impure blood in black; pure blood in white)

The Circulā'tion of the Blood. Food, as we have learned, is made fluid by digestion and is absorbed from the stomach and the intestines into the blood. Let us now see how it and the oxygen taken in through the lungs, are carried to all parts of the body by the circulation of the blood.

The blood containing this digested food is carried by the veins (v) to the heart, emptying into the right upper room (1); then into room (2), the lower right room. From this room the heart sends it to the lungs, where it gets oxygen and gives up its impurities. It then goes back to the left upper room (3) of the heart, and then into the left lower room (4), from which it is pumped out through the artery (A) with so much force that it reaches even the farthest parts of the body. In the capillaries (kăp'illaries) (c), it gives both its nourishment and its oxygen to the tired and hungry cells of the body, and collects and takes away their waste material, or impurities. It then returns through the vein (V) to the right side of the body from which it started, completing its circuit.

NOTE-BOOK

To what order of animals does the squirrel belong?

From what characteristic does it get this name?

Tell what you can about the squirrel's coat.

How are squirrels and monkeys alike? How different?

Which can run better up the side of a tree, a squirrel or a monkey?

What prevents a squirrel from being hurt when it jumps from a high tree to the ground?

Tell about the teeth of the squirrel. What teeth has the cat that it has not?

Draw the skull of a rodent.

How does the squirrel get the kernel from a nut?

Write a short description of how it provides food for winter.

In what way does the mother squirrel protect her young?

Name the organs of circulation and give the use of each.

What important things does the blood do in the capillaries of the lungs? In the capillaries of the body?

Trace the food from the intestine to the hungry cells of the body.

BATS

Material needed:* A live bat to note its teeth, its weak hind legs and whether or not its tail is attached to the skin of its wings.

Malaysia may be said to be the home of the bats. Many species are found in the different islands of the archipelago, and thirty-five species are found in the Philippines alone. The largest of Malaysian bats is the fruit bat, sometimes called the flying fox from the shape of its head, and called the fruit bat because it eats fruit instead of insects, as common bats do. Some flying foxes are of immense size. They grow in the Celebes to be five feet from tip to tip of wings. Very large fruit bats are also found in the Philippines.

Common bats may often be seen at twilight darting here and there in search of insects. Their teeth are sharp-pointed and conical in shape, and are well adapted to catching and eating their food.

Bats sleep in the daytime. When sleeping they hang by their claws with their heads downward and their wings folded to their sides. Often many bats may be found hanging from the ceiling of a cave or from the limb of a tree. If shot

* Care should be taken, for bats bite severely.

and killed while thus sleeping, the claws are so strong that the bats often remain hanging in the same position after death.

In form and structure the bat is a most singular animal. The body is covered with soft brown or gray fur like the fur of a mouse. But the bat has wings and can fly through the air. It was long thought to be a bird with wings of skin. But the wings are not like the wings of birds. The front limbs, or wings, of the bat are long and the fingers are greatly

FIG. 33. Flying fox

FIG. 34. Skeleton of bat

spread out. A thin skin, or membrane, covers the fore limbs and fingers, and is usually joined to the tail also. Note that the toes of the hind feet are free.

Not only in covering and wings is the bat different from birds, but in other more important ways. The mother bird lays eggs from which the young are hatched, but the bat brings forth its young alive. While the little bat is young the mother carries it around with her. It holds on to the mother's fur tightly while she is flying. The little bat lives on its mother's milk, like a kitten, until it is old enough to get its own food. Name as many animals as you can that are nourished by milk

when young. Animals that are nourished by the mother's milk when young are called mammals (măm'mals).

NOTE-BOOK

Because of what is the fruit bat sometimes called a flying fox?

Why has the common bat so crooked a flight?

How do the teeth of insect-eating animals differ from those of other animals that we have studied?

What are the bat's habits in sleeping?

How are the front limbs modified for flight?

In what respect is the bat like the squirrel?

Make a drawing of the common bat, putting in the skin also.

How is the bat like a bird? In what striking way do they differ?

Why do we call the bat a mammal? How many of the characteristics of a mammal has it?

CHARACTERISTICS OF MAMMALS

1. Mammals are so called because the young are nourished by the mother's milk.

2. The mammals vary in size from the immense whale, that lives in the sea, to the tiny shrew mouse, one kind of which is found in the Philippines.

3. Mammals usually have four limbs on which they walk, two in front and two behind. Name a mammal that walks on only two legs? The fore limbs of the bat are used for flight, while the hind limbs are so weak as to be of little serv-

ice in movement. In the whale the fore limbs are paddle-shaped, or flipper-shaped, for swimming. The hind limbs are either rudimentary, or are entirely wanting.

4. The covering of mammals is usually of hair or fur of various colors. Fur is very fine hair that is short and thick. The whale is devoid of hair with the exception of a few scattering bristles around the mouth.

5. Mammals have three general kinds of teeth: (1) front or cutting teeth, called incisors (inçī'sors), (2) long, pointed tearing teeth, canines, and (3) back grinding teeth, called molars. These different kinds are adapted to the various kinds of food eaten. Carnivorous animals, like the dog or the cat, have the canines well developed for tearing the flesh. The front teeth of the carabao are made for cutting and the back or molar teeth, for grinding grass. The rodents, or gnawing animals, have the front teeth (incisors) long and sharp for cutting through solid substances, like wood. The common bat, however, which eats insects, has neither cutting nor grinding teeth, but it has sharp, conical little teeth that are better adapted for catching its kind of food.

6. The parts of the digestive tube are the mouth, the esophagus or gullet, the stomach, the small intestine, and the large intestine. In the digestive tube, food is changed completely into a fluid which is absorbed through the blood-vessels into the blood.

7. Mammals breathe entirely by means of lungs. The breathing tract consists of nostrils, nasal cavity, windpipe, bronchial tubes, or bronchi (brŏn'kī) and lungs. In the lungs the oxygen from the air passes through the walls of the tiny

blood vessels into the blood. And impurities, such as carbon dioxid pass from the blood out into the air of the lungs to be thrown out in breathing. Blood that has given off its impurities and taken up oxygen is of a scarlet color and is called pure blood.

8. The organs for the circulation of the blood are the heart, a pear-shaped organ, having four rooms—two on the right side and two on the left; the arteries, carrying the blood from the heart; the veins, carrying the blood to the heart; and the capillaries, very tiny vessels which connect the arteries with the veins.

The blood, carrying nourishment from the digestive tube, goes through the veins to the right side of the heart. From the heart it goes to the lungs where it takes up oxygen and gives out impurities. It then goes back to the left side of the heart, to be sent through the arteries to the capillaries all over the body. After it has given up its nourishment and oxygen in the capillaries and taken up the impurities it then goes back through the veins to the right side of the heart, completing its circulation.

SECTION II

BIRDS (CLASS AVES)

Birds are lower in structure than mammals, but in several respects they are more highly gifted. Their beautiful plumage, their melodious song, and especially their power of flight are characteristics in which they excel other animals.

Tropical birds are generally rich in color. Malaysia is the home of the most gorgeous of all birds, the birds of paradise. In our own islands there are many kinds of birds that are beautifully colored.

It is a singular fact, however, that the brightly colored birds of the tropics have a poorly developed song, and in some cases are almost silent; and that the birds of the temperate regions are quiet in color and possess the sweetest song. We shall see later why this is.

Nature's greatest gift to birds is the power of flight. By flight birds escape some of their swiftest enemies. A cat can catch a bird only by creeping upon it unawares.

The whole body of a bird of flight is a model of lightness. The covering is of light feathers; inside of the body are air sacs which serve as balloons; and even the bones are hollow and can be filled with air.

The wings are the principal organs of flight. They are in the same position as the front limbs or arms of mammals, and have parts corresponding to the arm, the fore-arm, the hand,

FIG. 35. Philippine sun-bird. Male above, female in nest (from Iloilo)

and even the fingers, except that there are three fingers instead of five.

Observe the parts and structure of a single feather, Fig. 36. The main stem is made of a hollow part, the quill, and a solid part, the shaft. Attached to the sides of the shaft are the vanes, or web (c). The vanes are made up of rows of barbs. If you should examine a feather under the low power of the microscope you would see that the barbs are connected by little hooks. These are the barbules (bärb′ūles).

From the part of the wing corresponding to the hand long quill-feathers, called primaries, grow; and from the fore-arm come the secondaries. The wings are provided with strong muscles that are joined to the breast-bone. This bone in birds of flight is shaped like the keel of a ship, and gives a broad surface for attaching the strong wing muscles.

The tail, also, aids in flight. It is usually formed of broad, strong feathers. When the bird is flying the tail spreads out and serves as a balance. Does the tail move in flight like the wings?

THE PIGEON

Material needed: A live pigeon in a cage.

A bird of very strong flight is the carrier pigeon. It is so swift and strong that it can fly sixty miles an hour. In former times, before the telegraph was invented, these pigeons were greatly used in carrying messages from place to place. If you cared to send a message from Iloilo to Manila, for example, a carrier pigeon, raised in Manila and sent to Iloilo and liberated, could be back with it in Manila within a few

hours. Their usefulness comes from their strong habit of always returning to the place where they were raised.

The wild pigeon is a type of bird common not only tc temperate countries, but to Malaysia as well. There are many kinds in the Philippines. These differ greatly in size. Some are only a little larger than an English sparrow, while others

FIG. 36. Feather: (A) quill; (B) shaft; (C) vane

FIG. 37. Wild Pigeon (From Davenport's Introduction to Zoology)

are almost as large as a crow, and have long wonderfully arranged tail-feathers.

The covering of a pigeon is a bluish-gray above, with lighter colored feathers under the body. Rings of green sometimes surround the neck, and the breast is often of changeable colors.

The feet are pink and are covered with scales. They are provided with muscles so arranged that when the pigeon lights on a limb the weight of the body makes these muscles draw the toes together. In this way the bird is able to perch while sleeping.

The bill, or beak is made of a hard substance and is toothless. Does the pigeon have external ears?

Digestion in birds is different from that of mammals. The

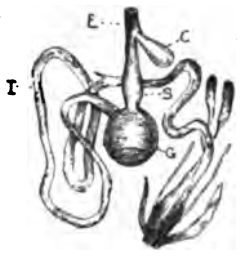


FIG 38. Digestive tract of bird: (C) crop; (E) esophagus; (G) gizzard; (I) intestine

FIG. 39. Brain of bird

pigeon eats grain and seeds and since it has no teeth the seeds are swallowed whole. They pass down the esophagus and enter a large sac, called the crop (c). Then they pass through a slightly enlarged part, the stomach (S) into the gizzard. In grain-eating birds the gizzard is a strong muscular organ, containing many little pebbles which have been swallowed by the bird. These pebbles grind the food fine and it then passes into the intestine and is taken up as in mammals. Cut through the muscular gizzard and notice its inner walls and the pebbles.

The lungs of the pigeon are two in number, as in man. Branching off from the lungs are many tubes which carry air to the air sacs and to the cavities of the bones.

The pigeon has a well developed nervous system, but the brain is not large. The outside of the brain of a bird is not rough or wavy, like the brain of most higher animals. The waves are called convolutions (kŏn'vo lū'shuns) and are an evidence of intelligence.

Life History. The pigeon usually makes its nest on the ground of leaves and sticks. The little ones are hatched from eggs. At first the birds are blind, without feathers, and helpless. The parent birds feed them food secreted by their crops. Soon the little birds are old enough to eat seeds and to take care of themselves.

NOTE-BOOK

How do birds compare with mammals in covering; in movement?

Where are the brightest birds found? The song birds?

What things make flying easy for a bird?

Compare the wing of the bird with that of the bat.

Draw a feather and letter its parts. How are the barbs held together?

Where are the strongest feathers found in the pigeon?

Why is the carrier pigeon better for carrying messages than the common pigeon?

What enemy has the pigeon that it can not escape by flight?

How is the tail of use in flying; in alighting?

Why doesn't the pigeon fall off when it sleeps?

How is its ear protected?

In what respect is digestion in birds different from that of mammals?

Gravel swallowed acts like teeth: where is it found in the bird?

What are the advantages of having air-tubes leading to the bones?

What about the brain of the pigeon shows that it has not much intelligence?

Tell about the nesting habits of pigeons.

PARROTS

Practically all of the Malaysian islands have representatives of the parrot family, but possibly the largest and most richly colored ones come from the Moluccas.

Some kinds of parrots fly well, but others rarely ever fly. Their feet are so made that walking on the ground is difficult. The parrot has four toes like the pigeon, but the toes are curved and can not be placed flat on the ground. The feet are best adapted to climbing. When the bird climbs, two of the toes grasp the limb in front, and two from behind. The parrot's beak is also of help in climbing. The upper part is long and curved. Watch the movements of a parrot.

The plumage of some parrots is remarkably beautiful. The parrot, probably best known in the Philippines, has dull green plumage and a red beak. This kind lacks the beauty which the fine crimson parrots possess, nor is it so striking as the racquet-tailed parrot found in Mindanao and the Celebes.

One kind of parrot is called the cockatoo. It is found

throughout Malaysia, but extends no farther to the west than the island of Bali. Only the white cockatoo is found in the Philippines. In the Celebes and Moluccas there are several kinds. Some are white like the Philippine cockatoo with the under side of the wings pink or yellow. Others are crimson, and one kind is black. On the top of the head is a crest which is pink, or yellow, or red, and which can be raised or lowered as the bird likes.

FIG. 40. Parrot (From Davenport's Introduction to Zoology, after Wilson)

But the most remarkable thing about parrots is not their brilliant plumage, nor the fact that they climb instead of fly, but it is their power to talk. Parrots can be taught to imitate human sounds. In fact they talk so distinctly and laugh so naturally that sometimes we are completely fooled by them. South American parrots are the best talkers. The common

FIG. 41. Cockatoo (Photograph by Frank M. Woodruff)

Philippine parrot can talk very well, but generally the cockatoo can be taught to say only a few words.

NOTE-BOOK

In what ways of travel does the pigeon excel the parrot?

Why can the parrot not walk well?

How does it climb?

What is the peculiarity of a kind of parrot found in Mindanao?

Compare the cockatoo with the common parrot.

What is the use of the crest?

How are parrots unlike most other birds?

When these birds learn to use words of the human language can they make other parrots understand them?

BIRDS OF PREY

Material needed: It may be possible to get a Philippine hawk for study.

Birds that feed upon animal life are called birds of prey. Among the Malaysian birds of prey are the eagle, the owl, and the hawk. All of these capture their food alive.

These birds have rather short, but very strong legs. Each foot has four curved claws called talons, with which they catch their food. The beak is so strong that it can tear to pieces any prey caught.

The Eagle. The eagles of the Philippines are not so large as those found in other parts of the world. In some countries there are eagles that are so large that they can carry off small animals and even very young children.

Owls. Several kinds of owls are found in the Philippines. Like bats, they sleep in the daytime and catch food at night. Owls are very fond of rats and mice, but they also catch birds and little chickens.

The Hawk. The hawk is a bird of strong flight. In some

FIG. 42. Philippine eagle (Photograph by Brown)

FIG. 43. Talon (Jordon and Heath, after Chapman)

respects it is like the parrot. In others it is very different. They resemble each other in having both the claws and the beak curved. The bodies are alike in shape, but the hawk is usually large and has not the bright plumage of the parrot. The common hawk, however, that we see sailing around in the sky, or over the water, is far from ugly. Its wings, tail, and

body are of a glossy brown, and its breast is of a snowy white color.

Food. Our common hawk preys upon birds and fishes. Often it may be seen circling over the water in search of fish. It sails around and around until it sees a fish, then it darts down like an arrow and carries it away. Did you ever see a hawk while flying, eating the fish that it had caught?

The hawk is also fond of little chickens and of pigeons. A bird that has not a strong power of flight has little chance for its life if a hawk cares to make a dinner of it.

Few animals have a keener sense of sight. Although it sails very high it can see a small chicken far below it on the ground, and darts upon it so surely and so quickly that the chicken has no chance of escape, unless its mother has warned it to hide.

NOTE-BOOK

In what respect are birds of prey unlike other birds?

Name those found in the Philippines. Are they harmful or beneficial to man?

Give three organs that help them in getting their food.

Draw the talons.

What is one of the most common of the birds of prey?

Describe the color of the common hawk.

Compare the hawk with the parrot.

What is its food and how does it get it?

PHEASANTS

The pheasant (fĕz'ant) is a native of Asia, but it is now found in almost all parts of the world. Malaysia has several

kinds. In Borneo and Sumatra is found the largest of all kinds, the Argus (är'gus) pheasant. This bird was named in an odd way by the Greeks from a peculiarity of its feathers. Argus, one of the gods worshipped by the ancient Greeks, was said to have had a hundred eyes which he gave to this bird, putting them down the center of each of its long feathers.

By these dark eye-like spots down the center of the feathers the argus may be distinguished from other pheasants. The

FIG. 44. Pheasant (Jesuit Museum, Manila)

one in Fig. 44, however, has something of the same appearance, though it is very much smaller in size and each feather has but a single eye. The secondary wing feathers and the central tail feathers in the argus are very long; the tail sometimes grows to be six feet in length. The male has a habit of spreading his tail and dragging his long wing feathers on the ground as he struts along showing his splendid plumage to his admiring followers.

The common pheasant, found in the Philippines, is not so

large as the argus. It has much the general shape as Fig. 44. Around the eye there is a bare place that is usually highly colored. The head has a topknot, but the topknot can not be raised and lowered like that of the cockatoo. Did you ever see a chicken with a topknot? Pheasants and chickens are closely related.

The body of the pheasant is heavy, the wings short, and the tail is so long that the flight is poor. Can a chicken fly well? The tail in a common pheasant is about twenty inches long in the male and twelve in the female.

The common pheasant has spurs like the game-cock. The pheasant in our illustration has two spurs on each leg, but the argus is without spurs. Of what use are spurs?

Habits. Pheasants are so very wild that it is a difficult matter to study the habits of one not in captivity. Naturalists tell us that they may often be heard but seldom seen in the woods. They eat various kinds of food such as seeds, berries, and insects. Usually they live alone, but in the mating time a male gathers around him a number of females. They make their nest on the ground out of sticks. Each female lays from twelve to twenty eggs. The eggs require about three days longer to hatch than the eggs of a hen. How long does it take a hen's eggs to hatch? The mother pheasant has very little love for her young. Hens will fight to keep their chickens with them, but the mother pheasant seems just as well contented when her offspring are with other pheasants as when they are with her. But this does not seem to bother the little pheasant, as it is so independent that it can take care of itself from the first.

NOTE-BOOK

Why was the argus so named?

Compare the common and the argus pheasants, in size, in length of tail. How do they differ?

Give three reasons why a pheasant can not fly well.

Name some of the pheasant's relatives.

Tell two ways in which the common pheasant and the chicken are alike. In what do they differ?

Which is hardier a young pheasant or a young chicken?

HERONS

A bird which is very common in the Philippines, and found generally over Malaysia, is the heron. Our common heron is about twenty inches high, with a long, slender neck and even longer legs. Its body is graceful in form and is covered with neat, white plumage. The plumage of the egret (ē-grĕt'), Fig. 46, is of unusual beauty. A soft fluffy crest covers the head, and long delicate feathers hang down from the breast. From the shoulders spring fine silky tufts that spread out over the back and tail. These feathers are worn in ladies' hats and are valuable commercially.

While the heron has strong wings and is a good flier, yet its chief characteristic is its long legs that fit it for wading. The legs are bare more than half-way up to its body and are covered with pinkish scales. There are four toes, the fourth one extending backwards and placed flat on the ground. In a few wading birds the toes are webbed for swimming, also, but this is not true of the heron.

The heron wades out into the water and pretends to be

asleep, drawing its head back between its wings. Soon a fish, or other water animal comes along, and the heron darts out its long, slender neck and pierces it with its long bill. The bird's beak is strong and well adapted to catching food in this way.

FIG. 45. The Heron (Jesuit Museum, Manila)

The plumage of the heron is always clean and glossy. Water that falls on it does not wet the plumage but rolls off in large drops. This is because the feathers are carefully oiled from the oil-gland that is just above the tail. Did you ever see a chicken oiling its feathers?

Most kinds of birds shed their feathers once a year. This is called molting. Usually all of the feathers do not come

FIG. 46. Egret (Photograph by Frank M. Woodruff)

out at the same time, but one by one. In some birds, however, so many come out at once as to make flight impossible, and the bird is left unprotected until new feathers grow. The heron molts more slowly. In the Philippines, it molts about May. The new feathers around the neck are, at first, a light brown color.

NOTE-BOOK

Draw either the heron or the egret.

Which is more graceful, a bird like the heron with a long neck and long legs, or one like the wild duck that has a long neck but short legs?

Describe the Philippine heron.

In what respect is the egret different from the common heron?

Of what use to the heron are its long legs? What is their position in flight?

Why can't the heron swim?

Tell how this bird is a good fisherman.

Why will water not stay on the back of a bird? Explain what is meant by molting.

THE CASSOWARY

A giant among birds is the cassowary (kăs'so-wary). Its home is in Australia, but it is also found in Ceram, one of the Moluccas. The cassowary grows to be almost as tall as a man. Its body is strong and heavy. This bird is related to the ostrich of Africa which is so valuable for its plumes. But the cassowary has no rich plumage. Its body is covered with long, black, hair-like feathers.

The cassowary is too heavy for flight so its wings are undeveloped. Growing from each wing is a group of long, sharp spines. The longest ones are sometimes a foot or more in length, and are said to be used as organs of defense. Do you suppose that the cassowary has strong wing-muscles? The

FIG. 47. Cassowary (Jesuit Museum, Manila)

cassowary differs from common birds in not having a keel-shaped breast.

The legs are very big and strong. Each foot has three toes instead of two, like the ostrich. When the cassowary is running it kicks up its heels in a very awkward fashion, but it is so fleet that a horse can hardly catch it. It has a peculiar way of protecting itself. Of course, its way of escaping is by

running, but if it is overtaken it proves very dangerous. It rushes against an enemy and if it can knock him down, it kicks him backward and forward until he is often badly injured.

The head of the cassowary is crested. The neck is bare and of a blue color. How does this compare with the head of a turkey?

Food. The cassowary likes to live in the mountains where it can find berries and seeds. It is very greedy and when in captivity, it eats most anything.

Life History. These big birds live in pairs and build their nests on the ground. The ground is scratched out and a few leaves and sticks are put in as a lining for the nest. How large around do you suppose the nest would be? The female lays from three to five eggs. These eggs are four or five inches long. They are somewhat rough and of a greenish color. The male and the female take turns in sitting on the eggs until they are hatched. Do both the male and the female of the chicken sit on the eggs? The young cassowary is covered with down, and has no helmet at first, but in a few months its crest grows and the down gives way to the long, hair-like feathers.

NOTE-BOOK

Draw the head of the cassowary.

Why is the cassowary called one of the giant birds?

Describe its size.

How do the cassowary and ostrich differ in color and plumage?

Give two reasons why the cassowary does not fly.

Describe the organs that grow from its wings.

Why has it not a keel-shaped breast?
How do its feet differ from those of the ostrich?
For what does it use its legs?
Write a short description of the cassowary's nesting habits.

BIRDS OF PARADISE

The most beautiful of all birds is the bird of paradise. These birds are found in no part of the world except Malaysia. Most of them are in New Guinea, but some are found in the Moluccas. There are many species of them named, but only a few kinds have been studied while alive and in their native forests. They are so wild and so swift in flight that it is difficult to learn anything about their habits. Many of the species are known only from skins that have been brought from the deep forests by the native bird hunters.

The best known kinds are the king bird, the six-shafted, and the great emerald. These vary in size. The king bird is only about six and a half inches long, while the great emerald measures almost a foot and a half from beak to end of tail.

Most of the birds of paradise have some peculiar formation of feathers which gives them a remarkable beauty. Generally it is a gorgeously colored tuft that springs from under the wing and can be made to stand up like a fan. In the great emerald this tuft forms a shower of long silky golden feathers.

The peculiar feature of the king bird is two long-shafted feathers that spring from the tail, cross each other, and end in a beautifully coiled web. Note that the web, or vane, is formed only on one side of the shaft.

In the beautiful six-shafted bird three feathers spring from each side of the head, and terminate in a double web, like an arrow point.

Capturing the Great Emerald. It is most difficult to get near enough to these birds to shoot them. Mr. Wallace tells us of how the natives capture the great emerald. The males of this bird have a habit of collecting in the top of some tall

FIG. 48. King-bird (After Figuier)

FIG. 49. Six-shafted Bird of Paradise (After Figuier)

tree very early in the morning to display their plumage. When the natives find the tree which the birds have selected for their contest, they build a little platform in the tree during the day, and roof it with palm leaves. Early in the morning, before the birds begin to come, a man conceals himself under the thatch, armed with a bow and some blunt arrows. Soon the call of the bird is heard, and, one by one, the males alight

on the tree. They fly excitedly from limb to limb, spreading their gorgeous plumes proudly. When they are making the greatest noise and are most jealously showing off their great beauty, the bowman begins to shoot them with his blunt arrows, stunning them and knocking them to the ground where another man catches them. The birds are so excited that they do not notice the fate of their companions, and it is some time before they take flight and fly away.

Col'ora'tion We are ready now to see why tropical birds are generally brightly colored, and the birds of temperate regions, quiet in color. You have noticed that a grasshopper is easily seen when flying, but is almost invisible when it alights on the ground. If the grasshopper were colored some bright color, as red, or blue, would it be in greater or less danger of being eaten by its enemies? So it is with dull-colored birds. They often live on the ground. Some of them are so nearly the color of the dead leaves and ground that they can not be seen a few feet away.

But tropical birds live among trees with brightly colored leaves and blossoms, and their colors harmonize with their surroundings.

The male bird is usually more brightly colored than the female, and when she selects her mate she generally chooses him for his gay coat. Then you may ask how the dull ones get their mates. Instead of with their bright plumage, the sober brown and gray birds charm their mates with their sweet songs.

Thus you see that color serves the bird in two ways—in selecting a mate, and in protecting it from its enemies.

SECTION III

1. REPTILES (CLASS REPTILIA)

Reptiles look little like birds, but in structure the two are much alike. When the world was a good deal younger than it is now, birds were even more reptile-like. Some of them had sharp teeth, and long lizard-like tails that were provided with peculiarly arranged feathers. Men in digging in the ground have found skeletons of these former birds, preserved in the rocks.

THE HOUSE LIZARD

Material needed: (1) Lizard's eggs found in crevices; (2) live house-lizard to note breathing and movement.

One of the smallest of the reptiles is the little house lizard commonly seen on the ceiling at night. This lizard is not so highly colored as most lizards are, but in general it is sufficiently typical of the lizard family to make it a good form for study.

The body is divided into distinct regions, head, neck, trunk, and tail.

The head is small and pointed and the pupil of the eye is slit-shaped. The eyes in most lizards are provided with movable lids, but geckos—like the large wall lizard—are exceptions to this. Has the eye of the house lizard movable lids? Some of the larger lizards, for example the monitors

—lizards often wrongly called iguanas in the Philippines—can bite severely, but the bite is not poisonous. The teeth in the house lizard are sharp-pointed and small. In the monitors the tongue is long and forked and is used as an organ of touch. Is the tongue of the house lizard forked?

The trunk is somewhat flattened. If you notice closely

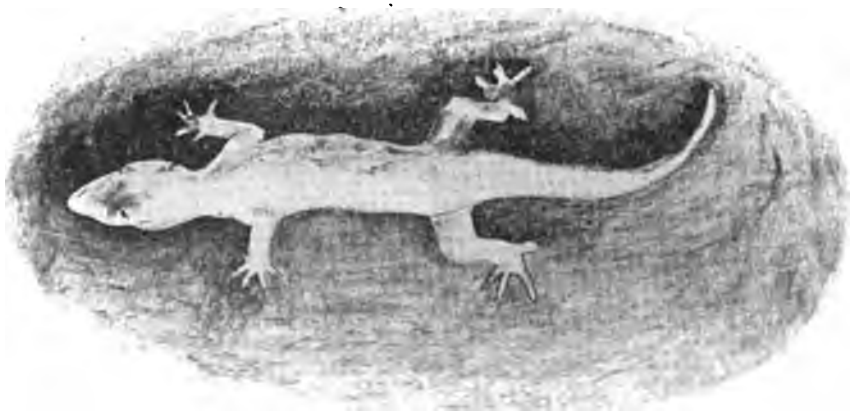


FIG. 50. House-lizard

you will find that the body is covered with minute points, or scales. In most lizards the scales are larger and flatter than in this form. There are two pairs of limbs of almost equal length.* You have doubtless wondered how this lizard runs around on the ceiling without falling off. Its toes are spread out into hollowed disks and when these disks are pressed against a flat surface they hold fast.

The tail in the house lizard is about equal in length to the

* This is not true of all lizards, however. In some the legs are very small and weak; others have only front legs; and still others are entirely limbless.

body, but in such forms as the monitor it is longer than both the body and the head together. You may have noticed how easily a lizard, if caught by the tail, will shake its tail off. This is because of the way the bones of the tail are made. The backbone of an animal, as you know, is made up of many pieces, or separate bones. Each one of these separate bones is called a vertebra (vēr'te-brȧ). The vertebræ (plural) of the lizard's tail have partitions of cartilage running through the middle. When the tail is struck it breaks in two at one of these partitions and falls off. But strange as it may seem the tail grows out again.

Food. As soon as the lamps are lighted at night we may see the little house lizards coming out upon the ceiling, one by one, getting ready for a mosquito and moth dinner. Soon an unfortunate moth comes flying in to the light. No sooner has its fluttering been heard than every little lizard stands attention. The moth strikes the ceiling and the lizards, with tails wiggling, await impatiently for it to alight; then they dart at it and the nearest hungry little mouth grabs it, gives it a few savage little shakes, and swallows it down.

It would be difficult to say how many insects, such as moths and mosquitoes, are thus destroyed in a single night by house lizards alone.

Lizards have an odd way of drinking. If they are thirsty they stick their tongues into the water a few times. This gives them all they care for for the day.

Life History. Eggs of the house lizard are laid in cracks and crevices and are left to be hatched by the heat of the sun. In most kinds of lizards the egg has a soft shell, but in

the geckos it is hard-shelled. From the eggs you have collected you will be able to learn of the size of the young at first, and whether, or not, it is like the parent when first hatched.

NOTE-BOOK

In what way were some of the birds of many years ago more like reptiles than at present?

Draw the house lizard.

Why does it like to stay on the ceiling?

In what two ways is the covering of this lizard different from that of the common lizard?

Name the regions into which the body is divided.

Which region is the longest in most lizards? Is this true of the house lizard?

Are the eyelids of the house lizard like those of the gecko or of the common lizard?

Compare the tongue in different lizards.

Describe the limbs.

Give the number of toes on each foot, and explain how they are of special use.

How is a vertebra in the tail of a lizard different from one in the back?

Why should we not kill house lizards?

Observation: Learn if you can whether or not the bone also grows again when the new tail is formed.

THE SNAKE

Material needed: A living snake in a glass jar. Note tongue and scales.

We have seen that birds are fitted with wings for flight and that reptiles, like the house lizard, move by means of legs. But we have now come to study a reptile, the snake, that has neither wings nor legs, and yet that can move rap-

FIG. 51. Rice snake (Jesuit Museum, Manila)

idly on the ground or in water, and that sometimes even climbs trees.

The body of the snake is covered with scales which are larger and flatter than the scales of the house lizard. They grow from the true skin and protect all parts of the body.

Every year the snake sheds its outer skin and comes out with a bright new coat. Did you ever find the old skin?

The scales, or ventral shields, under the body are large and extend from side to side. They are attached to the ends of the ribs, and it is by the movement of the ribs and ventral, or lower scales that the snake runs so swiftly over the ground.

The eye of the snake has no movable lid, but it is covered with a transparent skin. Can it close its eyes?

The tongue is long and forked and, as in the monitor, is used as an organ of touch. By licking its tongue out it is often able to frighten away its enemies. The tongue, when not in use, is withdrawn into a sheath.

The snake has only one well-developed lung. The blood, like that of all reptiles, is cold. Is the blood of birds warm or cold?

Snakes are found in most warm countries. Malaysia has a great number of them, but few are seen in the Philippines.

These reptiles may be divided into two general groups: those that are poisonous and those that are not. Both kinds are found in these islands. Of the poisonous type is the rice snake of Luzon. Fig 51. This snake, although small, is very poisonous. Of the second group is the python, or house snake.

It is of interest to know how a poisonous snake bites. (Fig. 52, c). In the upper jaw is a pair of long, tooth-like organs, called the poison-fangs. These fangs are hollow and are connected with a sac filled with a poisonous fluid. When the snake strikes, the fangs are driven into the flesh, and the poison flows out through the fangs into the wound. Poison

is of use to the snake in two ways. It protects the snake from its enemies, and it also helps in capturing food. The prey is paralyzed by the poison of the snake, but the snake can eat the food that is thus poisoned and not be injured by it.

The python likes to live in the ceilings of Philippine houses, and is said to catch rats that live there. This snake grows to be very large. It sometimes reaches nine meters (about 28 ft.) in length and grows to be as large around as a medium-sized bunga tree. It is of a yellowish-brown color, and is covered with dark spots that give a chain-like effect down the back.

FIG. 52. Head of snake: (A) tongue; (B) poison-sac; (C) fangs; (D) teeth

The tail in most snakes is a simple extension of the body, but in the python it is short and much smaller around than the body. In some of the large snakes the tail is used to wrap around limbs so as to let the body swing like a vine. In this way large snakes can surprise and capture animals that pass under them in the forest. But the tail of the python is too short for this.

The python is different from all other snakes in sometimes having a pair of rudimentary hind limbs under the skin near the end of the body. Note that when lizards have but a single pair of limbs present, it is the front pair.

This snake is not poisonous, but that does not mean that it is not dangerous. In fact, the body of the python is so big that it does not need poison in helping to kill its prey or to protect it from its enemies. If the food is not too large the

FIG. 53. Python (Jesuit Museum, Manila)

python swallows it alive. But if the prey is very large most big snakes kill it by coiling their body around it and crushing its bones. The jaws are very loosely joined together, and the ends of the ribs are free to spread out wide when large food is

swallowed. As a result of these two things the python is able to swallow animals that are larger than its own body. After a snake has had a heavy dinner it lies quietly for several days without catching more food until that which it has eaten has been digested.

In cold countries snakes sleep during the winter months. This kind of a sleep is called hibernation (hī'ber-nā'shŭn). While animals are hibernating they are nourished by the fat that they have accumulated during the other months.

Life History. Most snakes lay eggs, but a few have the young born alive. The eggs are covered with a soft shell. They are laid on the ground or buried in the earth. Very little heat is necessary to hatch them. The python has a very odd way of keeping its eggs warm by the heat from its body. Although snakes are cold-blooded, yet, when the python coils its body over the eggs there is enough heat in it to hatch the eggs. In a few snakes the eggs are kept in the body of the female until the little ones are hatched. Snakes when first hatched are perfect in form like the parent.

NOTE-BOOK

In what way is a snake different from a bird? From most other reptiles?

Is the body divided into regions as in lizards?

Compare the upper and lower scales of the snake in size and use.

Explain how a snake can run when it has neither feet nor legs.

How do the eyes of the snake compare with those of a lizard? How are they protected in the snake?

In what two ways is the snake's tongue peculiar?

What kind of teeth has it and why are they pointed backward?

Are the two long teeth, canines? Why are they hollow?

Draw the snake's head.

How does the snake breathe?

Why do some snakes use poison? Explain how the poison is put into the enemy.

Where is the home of the python?

Is it a harmful or a useful snake?

Why does it not need poison?

What two characteristics has the snake that makes it possible for it to swallow food that is larger than its body?

How do the rudimentary limbs of the python differ from the limbs of the two-legged lizards?

Why is a snake inactive after a heavy meal?

Explain how an animal is kept alive while hibernating.

How does the hatching of the python's eggs differ from that of other snakes?

CROCODILES

In form the crocodile (krŏk'odīle) is like the house lizard, but it is many times larger. In fact, it is the largest of living reptiles. The body in some is almost seven meters long from tip of nose to end of tail. The crocodile of Malaysia, however, is seldom more than four or five meters long. Figure 54 shows one from Mindanao that is five meters in length.

The body of the crocodile is covered with hard plates and is of a brown, or greenish-brown color. This covering is so great a protection that few enemies can pierce or injure it.

The crocodile has four feet, each front foot having five toes and each hind foot four. The hind feet are partly or completely webbed for swimming.

The head of this reptile is large. Its eyes are dull and glassy, and placed almost on top of the head. The eye has two lids as our eyes have, and, as in many other animals, there

FIG. 54. Crocodile, from Mindanao (Jesuit Museum, Manila)

is a third lid that can be drawn over the eye to protect it from the glaring sun. Note the position of the nostrils at the extreme end of the nose. Just behind the eye is a sunken place in the head. This is the ear. When the crocodile is under water, both the ears and the nostrils can be tightly closed. The mouth opens wide and shows jaws that are thickly set with round, sharp-pointed teeth. There is a kind of valve in the back of the mouth that closes and shuts out the water from the throat.

The crocodile lives part of the time in the water and

part on land. It can run on the ground, but it is most active in the water. Its long, flat tail serves as an oar that sends its big body swiftly through the water. The crocodile can dive under water but it can not stay long, for it must come up to breathe. When it comes up it fills its lungs, and the air-sacs, that are connected with them, full of air. It can stay under water only until the oxygen in the air is used up.

The heart of the crocodile has four rooms, like the heart of a bird. The blood is red but it is sluggish and cold.

Food. The crocodile likes to eat fish, and it often catches and eats other animals. People are also killed and eaten by them. This reptile has a peculiar way of killing its prey. It seizes the animal in its jaws and holds it under the water until it is drowned. Since its nostrils are at the extreme end of its nose it can keep the tip of its long nose out of the water to breathe and still hold the prey under water. Why does the water not run down the throat of the animal and strangle it?

Life History. The crocodile crawls out on the bank and lays from twenty to fifty white-shelled eggs in the sand. If left alone the eggs will hatch by the heat of the sun. Many of the eggs never hatch, however, for several kinds of animals like to dig them up and eat them. The little crocodile has the same form as the parent. When it is first hatched it is about the same size and looks much like our large wall gecko. The young dig out of the sand and make their way to the water. They grow very slowly and many years pass before they are as large as the parent.

NOTE-BOOK

How is the body of a crocodile protected?

Why are the hind feet webbed?

Draw the head.

Compare the crocodile with the gecko and snake as to eye-lids.

Of what advantage to the crocodile is it to have its nostrils at the extreme end of its nose?

When this animal is under water how does it prevent the water from entering its nose, ears, and throat?

What organs does it use in swimming?

How long can the crocodile live under water without coming up to the surface.

In what way is the blood of the crocodile like that of the bird; unlike it?

Why do we say that it has a highly developed heart for a reptile?

Describe the crocodile's way of killing its prey.

Is the life history of a crocodile more like that of a mammal or of a bird?

Compare the crocodile and the python in the way of caring for their eggs and young.

Describe the newly-hatched crocodile.

TURTLES

Material needed: If possible have a small live turtle for study.

There are many different kinds of turtles. They may be separated into two general divisions: turtles that live in the

sea, and those that live on the land. Those that live in the sea have longer fore legs than hind legs, and the legs are flipper-like for swimming. Sea, or marine turtles, are usually larger than the land forms. Some of them, such as the green turtle, the hawk bill, and especially the luths, or leather-back, grow to be of immense size; the one in Fig. 55 being two meters long and weighing nearly five hundred kilos (1000 lbs.).

FIG. 55. Leather-back turtle, caught in Manila Bay. Length 2 meters; weight 1,000 pounds (Jesuit Museum, Manila)

FIG. 56. Internal skeleton of marine turtle

Land turtles and sea turtles are alike in many ways. Both have two skeletons; one internal and the other external. The outside skeleton serves as a protection, and, with the exception of that of the leather-backs, is attached at the top to the inside skeleton. Do you know of another animal that has an outside skeleton? The outside case is made of two parts; one above, the carapace, and the other below, the plastron. In some of the land forms the head, legs, and tail may be completely

drawn into the shell. The turtle can not escape its enemies by running, so nature has given it a house that it can close against intruders.

Both kinds are alike in breathing by lungs. You would naturally suppose that turtles which spend most of their time far out at sea could breathe under water; but such is not the case. Like the crocodile the turtle breathes in a lot of air and then stays under the water until the oxygen is used up.

The turtle has a three-chambered heart and cold, red blood. How does its heart compare with that of the crocodile?

The turtle has no teeth. Instead, its jaws are covered with a hard, horny substance and the mouth is shaped something like the beak of a bird. Many animals have the power of moving the tongue very rapidly. In the monitor, for example, the forked tongue can be licked far out. But the turtle's tongue is immovable.

Turtles have been known to live a long time without food. One kind of sea turtle eats the roots of a sea-weed called "turtle grass." Others are carnivorous, that is, they eat the flesh of animals, such as fish.

The Green Turtle. Green turtles are good for food. In some countries men catch them in a strange way. Although these animals live in the sea, they come to the beach to lay their eggs. At certain seasons of the year, during the night they come in great numbers to the shore, and men go about with long poles and turn them over on their backs. The turtle can not right itself and so is helpless.

The Hawkbill. One of the most valuable turtles is the hawkbill, Fig. 58, which furnishes the "tortoise shell" of

FIG. 57. Capturing turtles (After Figuier)

commerce. The back of the shell, or top part of the outside skeleton, is made of thirteen plates that overlap one another. These plates are removed by heating them in hot water. They are then made straight by pressure. Sometimes two are joined by heat. Then they are polished and made into valuable articles of commerce.

NOTE-BOOK

Name two general kinds of turtles.

Which kind is the larger?

In animals, like the crocodile, that have both an external and an internal skeleton, are the two usually joined together?

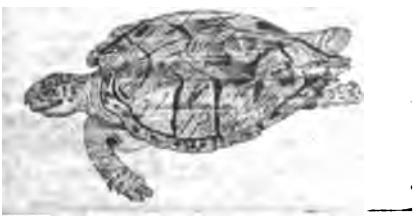


FIG. 58. The hawk-bill

What is the difference in the covering of the turtle and the snake?

Give the uses of the external and internal skeleton.

How do the feet and legs of marine turtles differ from those of land turtles?

Can the sea turtle withdraw its head and limbs as completely into its shell as a land turtle?

Explain the breathing of turtles.

Describe the mouth of a turtle.

Compare the tongue of the lizard and snake with that of the turtle.

What does the turtle eat?

How are green turtles caught and what are they used for?

By what characteristic would you be able to distinguish the hawkbill; is it found in the Philippines?

Describe the "tortoise shell" of commerce. Name some things made from it.

2. FROGS (CLASS AMPHIBIA)

Material needed: (1) Frog eggs and (2) tadpoles to study development; (3) frogs to see their method of breathing and movement.

Frogs are shy little creatures and are seldom found in the daytime. They often may be heard, however, croaking around ponds of water after a rain.

Frogs are not reptiles. They belong to the class called amphibians (ăm-phĭb'i-ans). The young of reptiles, as you know, are like their parents. The young frog, however, differs so greatly from its parents that it was long thought to be a different kind of animal. The word amphibian signifies an animal of two lives (amphi, both, and bios, life). In its young state the frog lives its life in the water; later it comes to land to live and breathes air.

The body of a frog is short. There is neither a true neck, nor a tail. There are no ribs and the vertebræ toward the tail have grown together in a peculiar way, causing a hump on the frog's back.

The skin, unlike the skin of any other animal that we have studied, is without a covering of hair, feathers, scales, or plates. In most frogs it is of a brown or green color on the back with white or yellow underneath. It is always moist and serves in respiration.

The limbs have the same number of parts as the limbs of man. The fore limbs are divided into arm, forearm, and hand; the hind one into thigh, shank, and foot. There are

FIG. 59. The Frog

FIG. 60. Flying Frog (After Wallace)

four fingers present—a fifth is sometimes present—and five toes. The toes are usually webbed. Unlike the lizards neither the fingers nor the toes have claws. The hind legs are longer and stronger than the front legs and are used in hopping. When the frog is not jumping it doubles these legs up under it.

Malaysia has one kind of frog that has its feet webbed into wings. The feet do not move in flight as do the wings of birds. When this frog lights on a tree it climbs up the trunk and then sails to another one and climbs up as before.

Frogs spend much of their time around the water. They do not, however, like salt water. When they are disturbed they dive under but soon come up for air. How does the frog swim?

The frog's mouth is very wide. If you should look you would find rows of tiny teeth in the upper jaw. The tongue is not fastened to the back of the mouth as in other animals, but is attached to the front part of the lower jaw. The back part of the tongue is loose, and can quickly dart out and catch an insect. There is no outer ear but back of the eye is a tight, smooth skin that is the head of the ear-drum. How many nostrils has the frog?

The lungs of the frog are simple air-sacs. In breathing the frog, like the turtle, gulps down a lot of air. As was said in studying the skin, much of the respiration is carried on by the skin.

Usefulness. Frogs are very useful in destroying harmful insects. The hind legs of some kinds of frogs are white and tender and make excellent food.

Life History. The life history of a frog is most interesting. A jelly-like mass of eggs is laid in a pond of water. A single female sometimes lays as many as a thousand eggs at a time. In a few days the eggs hatch into tadpoles and swim away in the water. At first they are fish-like in form and look nothing like frogs. Tadpoles, or polliwogs, have no eyes, no feet, and no legs. But they have long tails and tiny teeth. They live on very small water-plants.

When they are tired of swimming and want to rest, they

catch hold of something with their under lips. At this stage of their lives they have no lungs but breathe by means of gills. In a short time the hind legs begin to grow, then next the front legs. Eyes then form and lungs begin to develop. The tadpole can now breathe by either gills or lungs and for a

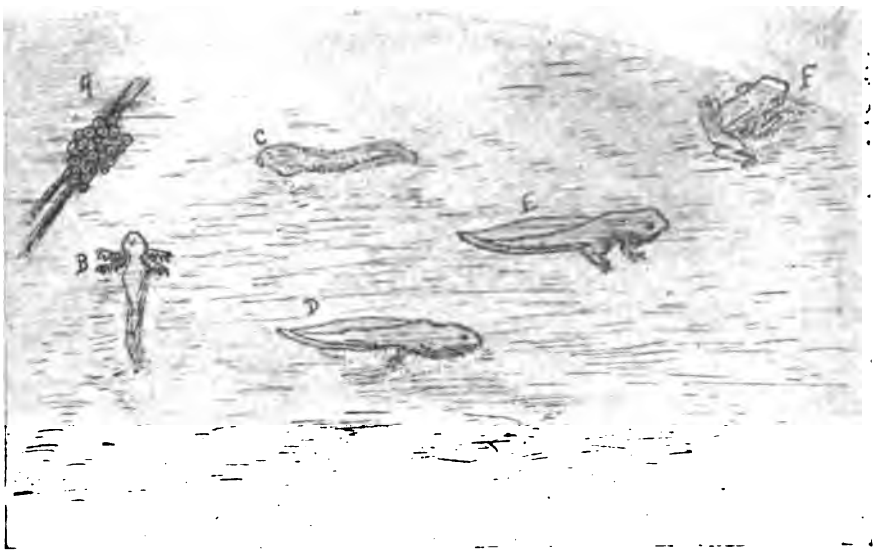


FIG. 61. Development of frog: (A) eggs; (B) tadpole with gills; (C) with gills absorbed; (D) with hind legs; (E) with fore legs also; (F) young frog coming out of the water

time both are used. Soon the tail becomes shorter and the gills wither away. Then the tadpole comes out of the water a little frog. As a frog, it eats insects instead of plants. It is probably five years before it is old enough to lay eggs, and it continues to grow several years before it is full grown.

NOTE-BOOK

Explain the meaning of amphibia.

Where are we most likely to find frogs?

How do the regions of the body compare with those of the lizard? What parts are lacking?

In what does the frog differ from all the forms that we have studied?

Compare the fore and hind limbs in number of parts; in use.

One kind of frog lives in trees. Do you suppose its feet are webbed?

Describe the flying frog.

How do the tongues of the frog and the snake differ in looks; in use?

How does the frog breathe?

From the eggs and tadpoles collected describe the changes that take place from the egg to the young frog.

Tell all the different ways in which the tadpole is like the frog.

3. FISHES (CLASS PISCES)

Material needed: (1) Fish in a large glass jar for a study of the breathing and swimming. (2) A ray.

The fish is the lowest form of backboned animals. In all vertebrates, as backboned animals are called, there is a small cavity inside of the backbone that contains the spinal cord and below this is a large cavity inclosed by the ribs, con-

taining the heart, digestive organs, and swimming bladder. You will notice that the upper cavity is surrounded by thick bone. This serves as a good protection for the delicate spinal cord.

The fish is adapted to living and moving in the water, but one kind, known as the flying fish, can sail through the air for a distance of a hundred meters, or more. It is a pretty

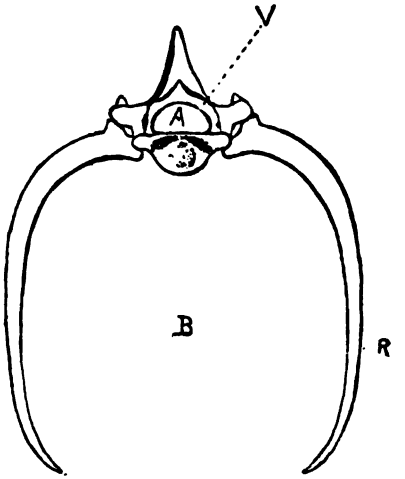


FIG. 62. Diagram vertebra and ribs of fish: (A) cavity for spinal cord; (B) cavity for internal organs; (R) ribs; (V) vertebra

sight when a vessel runs into a school of flying fish, to see them rise out of the water and sail away, their gauzy fins spread like wings, glittering in the sunlight.

Fishes have neither legs nor true wings, yet they move about freely and rapidly. What other animal travels without legs or wings? The fins of the fish take the place of limbs. Note that some of the fins are in pairs, while others are single. The pair of fins in front, Fig. 64, called the pec-

toral (pĕk'toral) fins, serves as fore legs; and two, usually behind these, the ventral fins, take the place of hind limbs. The other fins on the body, dorsal fins, or under the body, ā'nal fins, help in keeping balance and in rising and falling in the water.* All fish have not the same number of fins, but all of the fins aid in the movement of the fish.

Fins are made of a framework of bone or cartilage webbed with tough skin. The points of the bones are sharp and offer a good protection for some kinds of fish.

The tail, or caudal fin, is the principal organ of movement, however. Note the difference in the shape of the tail in different kinds of fishes, Figs. 63, 64, 66 and 67.

The fish has no well-defined neck, and the head is joined closely to the body. The jaws are set with sharp, needle-like teeth. 'Rows of teeth are also found in the roof of the mouth.

The eyes have no movable lids, so the fish can not close them. Do you suppose a fish sleeps?

The nostrils seem to be well developed, but if you try to run a bristle or a straw through them you will find that they are closed.

At each side of the head is a large, flat plate, the gill-cover. If you lift up the edge of the gill-cover a little, you will see some crescent-shaped openings, called the gill-openings, and the red gills themselves beneath. The gills are used for breathing. In animals that live under the water gills take the place of lungs. It is usually as impossible for a

* Experiment No. 3. To see the use of the different fins: Slip a rubber band over the fins separately. First the pectorals. Note the effect; next the ventral fins, etc. In each case notice the effect and record it in the notebook.

fish to breathe on land as for a man to breathe under water. Let us see how a fish breathes by means of its gills.

There is much air contained in the water. Water passes in at the mouth of the fish and over the gills. The gills are very full of tiny blood-vessels that take the oxygen from the air into the blood and give to the gills waste material (impurities) to be thrown out. Then the water passes out through the gill-openings. Compare this method of breathing with breathing by lungs. See pages 30 and 31.

Inside of the lower cavity of the body, in most fishes, is a

FIG. 63. Flying fish

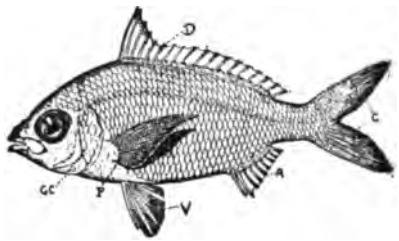


FIG. 64. Philippine fish, "duldul": (A) anal fin; (C) caudal fin; (D) dorsal fin; (Gc) gill-cover; (P) pectoral fin; (V) ventral fin

peculiar organ, the air-bladder or swimming-bladder. The swimming-bladder is filled with a light kind of gas and is in the same position as our lungs, but it is not used for breathing. By means of this swimming-bladder, the fish can make its body rise toward the surface or sink into deeper water. It supports the fish's body, like a balloon, so that the fish can rest quietly in the water at its pleasure. Our lungs help a little in the same way. If we are in the water we can float better if we first fill our lungs full of air.

The fish's heart has only two rooms, or cavities. Its blood is red, but cold. Name some other animals with a four-chambered heart; some that have warm, red blood.

Life History. Fishes usually lay many eggs. Some kinds have been known to lay millions within a few hours. If the

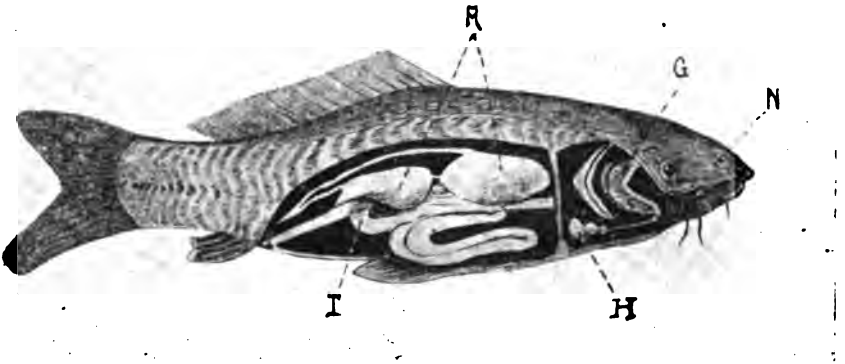


FIG. 65. Fish with side and gill-cover removed to show internal organs: (A) air-bladder; (G) gills; (H) heart; (N) nostrils; (I) intestine

eggs are not destroyed they will soon hatch. The young are like the parent in form except that the tail of a very young one is always shaped somewhat like the tail of the shark. See Fig. 66. At first the skeleton of the young fish is made of cartilage, but it soon grows hard and bone-like. Out of the millions of young that are hatched, only a few ever become grown. Why do you suppose this is? Is the life history more like that of the frog or the reptile?

THE SHARK

Fig. 66 shows a fish, the shark, that grows to be very large. The shark is a very low form of fish, however. Its body is a blue-black and is covered with thick skin. It has no over-

lapping scales as common fish do, but its skin, instead, is covered with many tiny points that make it rough like sandpaper. How does this compare with the skin of the house lizard?

Note the number of gill-openings.

The skeleton of the shark is different from that of many other fishes. It is not formed of bone but of cartilage. This sort of a skeleton, together with the peculiarly shaped tail, and the absence of a swimming-bladder, mark the shark as a low form.

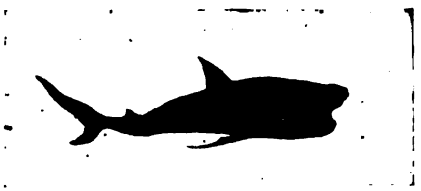


FIG. 66. The Shark (Jesuit Museum, Manila)

FIG. 67. Ray (After Jordon and Heath)

The mouth is not usually at the end of the snout as in common fishes, but it is farther underneath. It is well set with sharp, dangerous teeth that can easily bite a man in two. One kind of shark is called the man-eater. This one often turns almost on its back to catch its food. Why?

The shark is not good for food for it is a scavenger fish.

Some of these fishes bring forth the young alive.

THE RAY

Another even lower form than the shark, is the ray. The body of this fish is very greatly flattened. The side, or pectoral fins, are so large that they spread out fan-like on each side, extending from in front of the head back to the tail. See Fig. 67.

From the specimen you will see that the skin is like that of the shark.

The gill-openings, usually five in number on each side, are unprotected by a gill-cover. Unlike those of the shark, the gill-openings are close to the sides of the mouth, entirely underneath the body. The mouth is well adapted to feeding along the bottom. The teeth are flat for crushing such food as shell-fish.

The ray is much more sluggish in its habits than the shark.

The tail region in some of the rays is long and whip-like. In the sting ray a long spine grows backward from the upper part of the tail. This sting is very rough and is used as a defensive organ.

A peculiar kind, the electric ray, is so named because it is able to store up electricity for its defense.

THE SEA-HORSE

One of the most peculiar kinds of fishes is the little sea-horse, so common around the island of Cebu. Its body has a tough outside skeleton, covered with sharp points. But there are no overlapping scales. The tail is long and, instead of being round, is almost square. In swimming the tail is

curved forward instead of backward, as in the figure. At the end it is curved so as to hold to coral and seaweed.

The head and neck are shaped much like the head and neck of a horse. The nose is long and the mouth is at the end of it.

FIG. 68. Sea-horse (Photograph by Jas. G. Brown)

This little animal swims upright in the water, and is so nearly the color of its surroundings that it is difficult to find among the seaweed and coral.

Under the body of the male is a little pocket in which the female places her eggs. The male carries them around until they hatch, and then the little ones come out of this pocket and swim away.

NOTE-BOOK

What are backboned animals called?

Which is the highest form of backboned animal? the lowest?

Draw a vertebra with its ribs, showing (a) cavity for spinal cord, and (b) cavity for the heart, the digestive tract, etc.

Why does the spinal cord need to be carefully protected?

How does a flying fish sail?

What take the place of limbs in the fish?

How does the fish move forward? Up and down?

Describe the fish's teeth.

Can the eye be moved?

Count the gills. What is the use of the gill-cover?

Why can a fish not stay out of the water long at a time?

Explain how a fish breathes.

What is the use of the air-bladder, or swimming-bladder?

Draw the heart of a fish. How many rooms has it?

Why do fish lay so many eggs?

How does the shark differ from the common fish in covering; in tail; in skeleton; in fins?

Why is the shark not good to eat?

How does its life history differ from that of other fishes?

In how many ways is the ray like the shark? Different from it?

In what respects are the sea-horse and the common fish unlike?

From what characteristic did the sea horse get its name?

Describe its skeleton. Has it fins?

Of what use is its tail?

Make a drawing of the sea-horse.

How are the eggs of this fish better cared for than in most fishes?

INVERTEBRATES

SECTION IV

1. INSECTS (CLASS INSECTA)

THE GRASSHOPPER

Material needed: Grasshoppers in a bottle to study breathing.

The grasshopper (gråss'hŏpper) is called an insect (ĭn'sĕct). By insect we mean that the body is divided into parts, or sections. The body of an insect is usually divided into three parts; head, thorax (thō'rax), and abdomen (abdō'-men), or back body. (See Fig. 71.) The body of the grasshopper is not covered with skin as our bodies are, but with a hard substance, called chitin (kītin), that protects it from its enemies. This hard, outside part is the skeleton. Insects, and all of the forms that we shall now study, have no inside skeleton. Because they have no backbone they are called invertebrates (in, not; and vertebra, vertebrated, or backboned).

The head of a grasshopper does not turn freely on the neck because the neck and front part of the body are covered with a heavy hood. The grasshopper has two large, compound eyes. The compound eyes are divided into several thousand parts. It also has two simple eyes near the compound eyes. Look for a third simple eye. Has the eye of a grasshopper movable lids? The long horns are called feelers, or antennæ (plural, ăn-tĕn'-næ; singular, ăn-tĕn-na), and in some forms are

much longer than in Fig. 69. The antennæ, or feelers, of insects are used as sense organs. In the grasshopper they are used to touch or feel with; but some insects, such as moths and beetles, also use them to smell with; others, Fig. 79, to hear with.

Look at the mouth of a large grasshopper. Put a blade of grass to its mouth, and show with your hands how the jaws move in eating. When it is eating you will see a brown

Fig. 69. Grasshopper

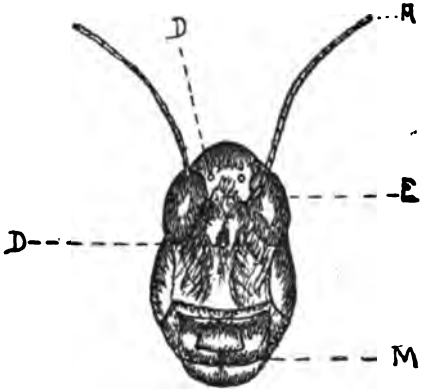


Fig. 70. Head of grasshopper: (A) antenna, or feeler; (D) simple eyes; (E) compound eyes; (M) mouth

juice in the mouth. This is of service to the grasshopper in softening its food.

The grasshopper is called a straight-winged insect because when the wings are closed they lie straight along the back. The wings grow from the thorax or body. The front wings are narrow and thick and the back wings are thin and fan-shaped. When the wings are closed the thick front wings protect the thin back wings. In both kinds of wings there are many veins. The veins act as a framework to make the

wings strong. They are also used to carry the colorless blood which nourishes the wings.

You also see that two kinds of legs grow from the thorax. Count them. When the grasshopper walks, all of the legs move, but the long legs are used especially to jump with. The long legs are strong and the grasshopper can jump very far. In Spanish this insect is called "saltamontes," which means, "jump a mountain." It is said that if a grasshopper were as large as a twelve-year-old boy, it could jump more than a hundred feet.

On the inside of the long legs is a rough surface. If you catch a grasshopper by the back, sometimes you can see what this is used for. But he is a timid little fellow and may not show you at first. If you are patient, though, you may see him rub his long legs against his front wings and you may hear the sharp, shrill noise which this rubbing makes. This is the grasshopper's call, or love note.

The back body, or abdomen, is made up of rings or segments and is much longer than the thorax. Is the thorax also segmented? Along the segments are many little holes. These are called breathing spores or spiracles (spĭr'ăkles). Note their movement in the living grasshopper. Hold a grasshopper's head under the water to see if it drowns. There is a depression under the wing that is larger than the spiracles. This is the ear of the grasshopper. The ear is very simple, so that this insect can not hear so well as we can.

There are four sharp points at the end of the back body in the female (of the short-horned grasshopper). These are called the ovipositors (ōvi-pŏs'itors). With them she bores

a hole in the ground for depositing her eggs. In cold countries the eggs are laid in the fall and do not hatch until warm weather comes in the spring; but here it is always warm and the eggs become tiny grasshoppers within a few days. At first the young grasshopper is without wings. It eats all the day and soon its skin becomes so small that it breaks open

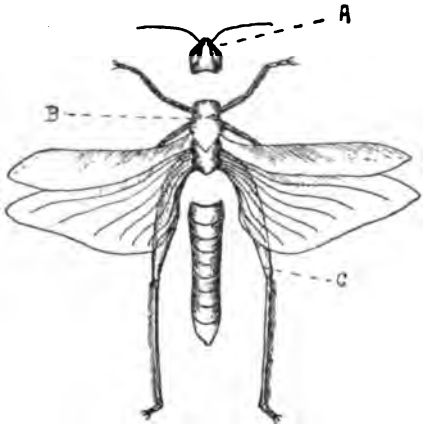


FIG. 71. Sections of grasshopper: (A) head; (B) thorax; (C) abdomen

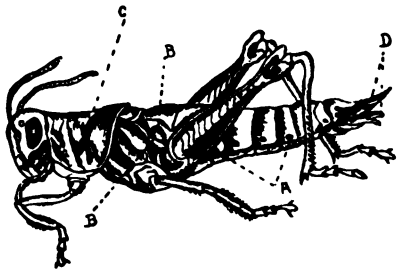


FIG. 72. Grasshopper with wings removed: (A) spiracles; (B) ear; (C) hood; (D) ovipositors

FIG. 73. Young grasshopper (Jordon and Heath, after Emerton)

along the back. The young one then crawls out of the old skin, and in a few hours a new skin forms. This first occurs when the grasshopper is about one-eighth of an inch long. This is the grasshopper's way of molting. The young one molts several times, then its wings begin to grow out and in a short time it is a large grasshopper.

Destructiveness of Grasshoppers. We have learned that the

grasshoppers lay their eggs in the ground. Many eggs are laid about the same time; so, many grasshoppers become grown at about the same time. Then they fly together from place to place. Sometimes in these islands they come in such swarms that they look like a dark cloud. They settle on the green fields of corn or grain, and when they leave after a few hours, the fields are brown and bare; not a green stalk can be seen. In some parts of the world grasshoppers cause the people much suffering from hunger, and sometimes they even bring a famine to the land. In the northern part of Africa they are a great pest. Once after an immense swarm had flown into the Mediterranean Sea the waves washed their dead bodies back to the shore, making a wall of them about two feet high for many miles along the coast. Since grasshoppers are such a nuisance various ways have been tried to destroy them. One way of killing them is by burning off the fields. In this way both the eggs and the young are destroyed. Another way is sometimes tried. It is to spread a disease among them by means of a fungus. Scientists have found that if this disease is given to a few grasshoppers, it soon spreads to others in the swarm, and kills them by the thousands.

NOTE-BOOK

Why do we call such animals as the grasshopper invertebrates? Name some other invertebrates.

Because of what is the grasshopper called an insect?

Name the parts of an insect.

Describe the skeleton of the grasshopper.

Draw the head.

How many and what kinds of eyes has this insect?

Give the number and use of the feelers, or antennæ. Are they formed of one solid piece or are they also segmented?

What kind of food does the grasshopper eat?

Compare the way its jaws move with that of the lizard.

How many wings has the grasshopper? Describe their shape and use. How are the wings made strong?

Why are grasshoppers called straight-winged insects?

How many legs are there? Give the use of the long legs.

To what part of the body are the legs attached? The wings?

How many segments has the abdomen? The thorax?

Tell about the spiracles; the ear. In which segment is the ear?

Do you know any way of distinguishing the female from the male?

How and why does the female bore holes in the ground?

Describe the development of the young grasshopper.

What ways are used to destroy grasshoppers when they have become a nuisance?

THE DRAGON-FLY

Material needed: Dragon-flies.

An insect almost as large as a grasshopper may sometimes be seen darting swiftly about in the air. It is often called a snake-feeder, but this name is misleading, for this insect does not feed snakes. Its correct name is the dragon-fly (drăg'on flȳ) or the mosquito hawk. Watch one closely as it flits about in the air and see why it should have this name.

The head of the dragon-fly looks as if it were made up largely of eyes. The enormous compound eyes in some of these animals are made up of more than twenty thousand parts. Each part of a compound eye is called a facet (făç'et). Simple eyes are not divided into facets. Look for simple eyes as in the grasshopper.

The wings at rest stand out straight from the body. Both

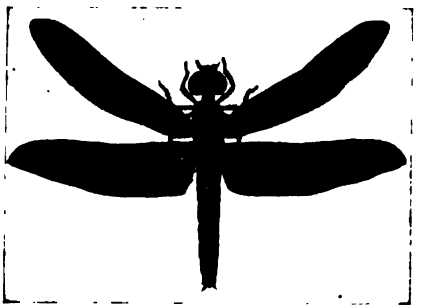


FIG. 74. Dragon-fly (Jordon and Heath)

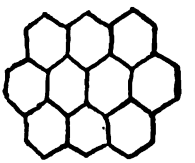


FIG. 75. Facets of compound eye

pairs are so transparent that you can see through them. They are thickly netted, and from the fact that the veins look a little like nerves, the dragon-fly and other insects of this type belong to the order of nerve-winged insects.

The long, slender abdomen is segmented. Note the breathing spiracles, and in the female the ovipositor.

Habits. The dragon-fly is harmless to man. Its jaws are not made for biting and the abdomen has no sting. This insect needs little protection, for it flies so fast that few enemies can catch it. It gets its food by preying upon troublesome insects. You may often see it just before night-time darting upon and catching gnats and mosquitoes. The front feet are

so arranged that it catches and holds its food with them. The mosquito hawk eats its food on the wing, so it does not have to stop often. Sometimes, however, it may be seen resting in a sleepy, motionless way on a twig near the water.

Development. At times a dragon-fly may be seen, when flying over a pond of fresh water, to bend the abdomen down

FIG. 76. Larva with mask unfolded

FIG. 77. Larva with mask folded over head

and touch the water with it. This is the way some kinds deposit their eggs. Others crawl down a stalk of grass sticking up out of the water and deposit their eggs on it, just beneath the surface of the water. The eggs in either case develop in the water and soon become larvæ.* The larva of the dragon-fly is called a water-tiger because it is so fierce to other small water animals. The water-tiger crawls along the bottom of the pond or stream and when it finds insects or their larvæ, it unfolds its great beak and makes at them. The beak has two strong incurved hooks, and when they close on a common larva, there is little chance of its escape. When not in use, the beak is carried folded up over the mouth, and is then called a mask.

At the end of the larval stage the young one crawls up a stalk of grass or stick, nearly to the surface of the water.

* The word lär'va means a mask; that is, the young is so unlike its parents as to hide its relationship to them.

Here it remains quietly for some time. It then sheds its old skin, crawls out of the water, and, after its wings unfold, it flies away.

White ants and ant-cows also belong to the order of nerve-winged insects.

NOTE-BOOK

Why is the dragon-fly called the mosquito hawk?

Name three ways in which the wings of a nerve-winged insect differ from those of the straight-winged form.

Are the wings and feet attached to the same segments of the thorax as in the grasshopper?

What are the feet best fitted for, standing, walking, or hopping ?

Draw some of the facets of a compound eye.

Compare its eyes with those of the grasshopper.

What is the difference between simple and compound eyes?

How many and where located are the simple eyes?

How do its feelers compare with those of the grasshopper?

Why has it so few enemies?

What kind of a bird is the dragon-fly most like in its habits?

Would you call it useful or injurious to man? Why?

Describe where and how its eggs are deposited?

How do their larvæ get the name of "water tigers"?

In what does the mouth of the young differ from that of the adults?

THE MOSQUITO

Material needed: (1) Put some wrigglers, or wiggle-tails, in a can of rain-water and study them from day to day

in their change to mosquitoes; (2) males and (3) females in bottles.

The mosquito (mŭs kē′tō) is a smaller and more graceful insect than the grasshopper, but it is also more annoying. A noiseless kind with long, banded legs, bites us through the

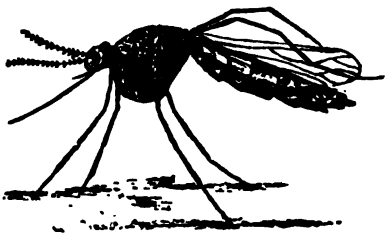


Fig. 78. Female mosquito

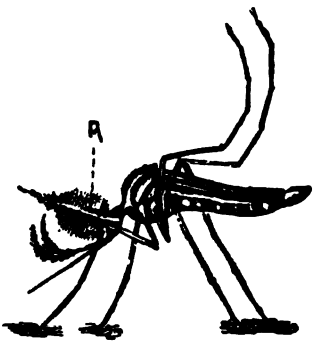


Fig. 79. Male mosquito (A) Auditory hairs

daytime, and yet another kind sings to us at night. These little insects have only two wings, but most of them can fly very fast. By moving their wings rapidly they make a buzzing or a humming noise.

The female is larger than the male, but the feelers of the male are more feathered and are used as organs of hearing.

The mouth of the mosquito is called a bill, and in the female it is well adapted to biting or piercing. The bill is composed of several parts. When closed there is an outside sheath, and within this, are six little needle-like bristles,—one of which is a sucking tube. Fig. 80. But the mouth of the male is a little different. He can not pierce the skin easily, so he seldom, if ever, bites.

The males usually live in the grass or woods and eat the juice of plants, but the females live on the blood of man or of other animals. If they can not get blood they eat the juice of plants.

When the female mosquito lights upon us, she easily pierces our skin with her sharp bristles. The bite hurts because the mosquito puts in a kind of poisonous fluid, or liquid saliva, to make the blood thin. Why is it better for the mosquito to have the blood thinned?

Life History. The mosquito lays many tiny eggs on the water. In about two days the egg becomes a larva and is called a wriggler, or a wiggle-tail. Watch the movement of the wrigglers that you have in the can of water. When eating the wriggler moves along the bottom of the vessel, but it often comes up to the top of the water to breathe. When it comes up its head is down and its tail is up, for it breathes through a tube in its tail. In a few days it becomes a pupa (pū′pȧ). Then when it comes up to the top its back is up and it breathes through two tubes in its thorax, Fig. 82 (P). While a pupa it does not eat, but it continues to move about. Soon the skin on its back splits open and it crawls slowly out, and floats around for a little while on its old skin as on a little boat. It has grown some wings but they are all crumpled and useless at first. If at this time there is rain or anything to upset the boat, the mosquito is drowned, but if not, the wings soon dry and it flies away. Why do mosquitoes not grow in running water?

The mosquito does not fly far from where it was raised. Sometimes a swarm of them is seen flying out of the grass.

They like to stay in the grass because it is damp, and because it protects them from the wind. When the wind is strong why do we not see many mosquitoes?

Mosquitoes and Disease. We sometimes have a kind of disease called malaria. This disease is caused by a germ that is found in the body of a certain kind of mosquito. If this

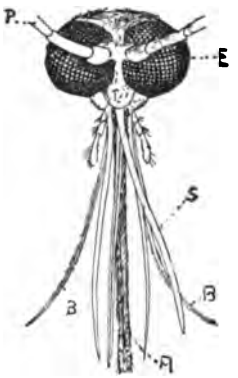


FIG. 80 Head of mosquito: (A) sheath; (B) bristles; (E) compound eye; (P) labial palps; (S) sucking tube (After Jordon and Heath)

FIG. 81. Young mosquito on boat

kind of a mosquito bites us it may put malarial germs into our blood. Another kind of mosquito is now known to carry one of the worst of all diseases, yellow fever. This kind of mosquito is found in these islands, but fortunately for us yellow fever germs have never been introduced into the Philippines. Other kinds of tropical fevers also are thought to be caused by mosquitoes. When mosquitoes bite a sick person and then another who is well, there is great danger that they will carry disease from one to the other. Thus you see

that mosquitoes are not only annoying, but also dangerous. If it were not that other animals eat them they would soon become a great pest. Fortunately, they have many natural enemies. Birds and dragon-flies catch them in the air, and fishes destroy them in the water while they are in the wriggler stage. We can protect ourselves from them by sleeping under mosquito nets, and we can also do much to destroy these

FIG. 82. Larva and pupa of mosquito, "wrigglers"

annoying insects. The best time to get rid of them is while they are wrigglers. Water that has been standing for some time is the best place for them to grow. Many may be destroyed by emptying all the cans and vessels that hold stale water. Sometimes dirty water stands under the kitchen. This is a good home for them and should be drained off. One of the best ways to kill the young is to put a little petroleum on the water. The petroleum stays on the surface

of the water, and when the wrigglers come up to breathe the petroleum goes into the breathing tubes and kills them.*

NOTE-BOOK

In what way does the mosquito compare with the grasshopper?

Name two ways in which the male and female differ as to looks.

Describe the mouth of the female.

Why does the male not bite?

What is the food of the male; the female?

Tell how the female's food is obtained.

Why does the mosquito's bite hurt?

How many wings has the mosquito? How does it sing?

Where are the eggs laid?

How does the wriggler differ from the pupal form in breathing?

Which is more active, wriggler or pupa?

When the pupa comes out of the old skin as a young mosquito, why can it not fly?

Why is its life in danger?

Name some of the natural enemies of the mosquito.

Write a short description of how mosquitoes may be destroyed.

Explain Experiment 4.

* Experiment No. 4. Fill a glass about two-thirds full of water that contains many wrigglers. After the water gets quiet, add a little petroleum to cover over the surface, and note the effect on the wrigglers as they come up to the top to breathe.

Describe in note-book.

THE HOUSE FLY

The house fly is another two winged insect. Its wings are so thin that you can easily see through them. Behind the wings are little pads called winglets, and near these are the balancers (B), two little knobbed hairs. In both the fly and the mosquito the balancers represent the back wings of such insects as the grasshopper. From which segment do the balancers come?

The head, thorax, and abdomen of the fly are distinctly

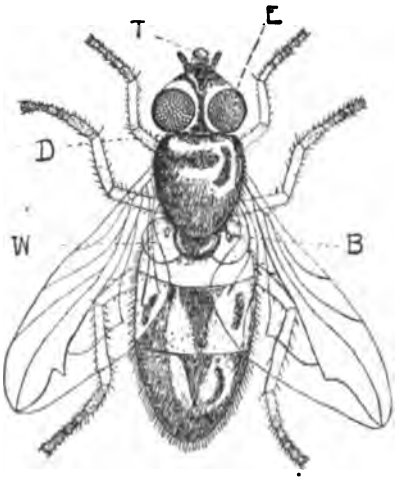


FIG. 83. Fly (B) balancer; (D) simple eye; (E) compound eye; (T) flattened end of tongue; (W) winglet (Burnet)

separate. The head turns on a slender neck that joins it to the body. How is it different from the neck of the grasshopper?

The fly has two short feelers. The eyes are compound but are divided into fewer parts than the eyes of the grass-

hopper. Note the number and position of the simple eyes. Try to touch a fly from any direction without being seen. The mouth of a fly is not adapted to piercing as a mosquito's is, but instead the tongue is hollow and flat at the end, Fig. 83 (T). The flat end is very rough in some flies and hurts when these flies "bite" us. If you watch a house fly eating, you will see that it laps its food a little like a cat drinking milk.

The foot of the fly is peculiar. It consists of two large hooks under the foot, and two flat pads. The hooks are of

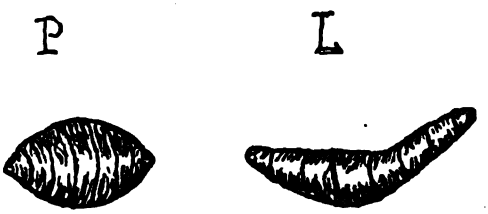


FIG. 84. Larva and pupa of house fly

help in clinging. Each pad is crossed by many fine threads and tube-like hairs which secrete a sticky substance that causes the foot to stick to the smoothest surface, so that the fly can walk on the ceiling upside down, or up a pane of glass, without the slightest danger of falling. Do you know any other animal that can walk on the ceiling? Can the grasshopper walk upside down?

The house fly is very fond of sugar or anything sweet. It also sucks sweat through its hollow tongue. Could the fly eat sugar with the sharp bristles that the mosquito has? Could the mosquito get the food that it likes with a tongue like the fly's?

The fly breathes through spiracles much as the grasshopper

does. Inside of the fly's body are two air sacs that are connected with the spiracles. These sacs help it to fly a long time by supporting its body. What other animal that we have studied has air sacs?

Life History. Flies lay eggs in filth, usually about stables. In a day or so the egg hatches and becomes a little white worm called a maggot. This little larva destroys much that would cause disease. Soon its body becomes segmented. At the end of a week the larva quits eating and becomes a pupa. The pupa is smaller and is covered with a hard, brown coat. As a pupa it is inactive. The pupa's skin next breaks along the back and the fly comes out full grown. Some people think that a little fly is a young one; while in fact it is only another kind of fly.

House Flies and Disease. The fly's feet are well adapted to carrying disease-germs. One scientist found thousands of germs on a bit of jelly where a fly had been eating. The fly walks over dirty things and then lights on our food. In this way germs are carried with our food into our bodies. During the recent cholera in these islands, it was believed by physicians that flies greatly spread the disease. Thus we see that while the larvæ of flies are useful, in a way, the flies themselves are a very great nuisance because they carry disease-germs.

NOTE-BOOK

How is the house fly like the mosquito?

Which has longer feelers, the mosquito or the fly?

How many simple eyes has the house fly and where are they?

Compare the mouth parts of the fly with those of the mosquito.

The fly bites and the mosquito pierces. Explain each.

How are flies and mosquitoes alike as to their wings? Unlike?

Describe the legs and tell why the fly can walk up a pane of glass.

Many insects of strong flight have air sacs. How are these used?

What form has the larva of the house fly? How is it useful?

Compare the pupa with that of the mosquito. (With regard to activity).

When the pupa of the house fly molts, what is it then called?

Write a short description of how the house fly carries disease-germs.

How can we prevent the spreading of disease by flies?

THE BUTTERFLY

Material needed: (1) Eggs, caterpillars, and cocoons to study development; (2) a few butterflies.

The butterfly (büt'ter fly) leads a happy life. Its home is among the flowers, and it spends its days eating nectar.

Thousands of different kinds of butterflies are known to man. They are named, sometimes, from the plants on which they lay their eggs. One kind, for example, a little white one, lays its eggs on the cabbage plant. It is called the cabbage butterfly.

The most beautiful butterflies in the world are probably

found in Malaysia. With the exception of the birds of paradise, no form of animal life is so gorgeously colored as some of these butterflies.

An unusual form of southern Asia is also found in Malaysia. It is called the "dead leaf" butterfly because of its peculiar habit of alighting on a twig for protection. In this

FIG. 85. Dead-leaf butterfly: (A) at rest; (B) in flight

position, Fig. 85 (A), it resembles a leaf so closely that it takes sharp eyes to discover it. In what way does this habit protect it?

The feelers (antennæ) of the butterfly are two in number, and usually smooth. At the end of each is a knob. The feelers are not only organs of touch, as with the grasshopper, but of smell.

The butterfly has compound eyes, but no simple eyes. In some kinds of butterflies each compound eye is divided into as many as seventeen thousand parts, or facets. The tongue is hollow and is much longer than the fly's. It is adapted to sucking nectar from the deep flower cups. When a butterfly finds a flower that it likes you may see it unroll its long tongue, and put it deep into the cup of the flower, to suck out the nectar, or sweet juice. When the butterfly is not

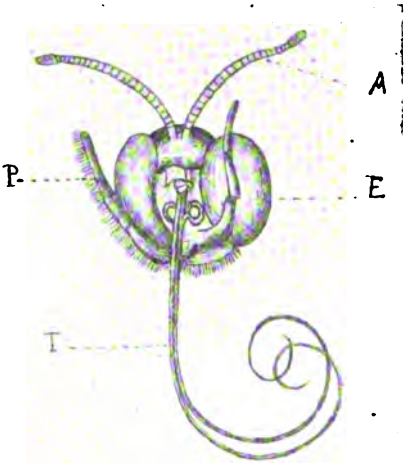


FIG. 86. Head of butterfly: (A) antenna; (T) tongue uncoiled; (E) compound eye; (P) palp

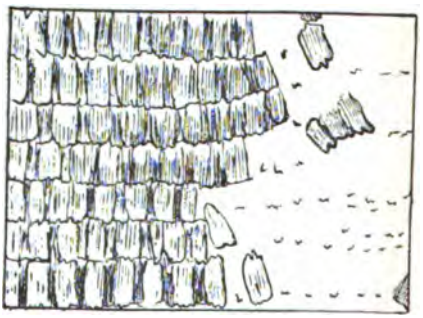


FIG. 87. Wing scales

eating, its tongue is coiled up under its head like a watch-spring. Catch a live butterfly and uncoil its tongue. Note how it is formed. Compare the method of getting food with that of the fly and mosquito.

In all typical insects the thorax is made up of three segments; each of which has a pair of legs attached to it. The butterfly has the same number of legs as the grasshopper.

How are they different? Which uses its legs more? What does the use of an organ have to do with its size and strength?

Since the butterfly uses its wings more than the grasshopper does, we shall expect to find them larger and stronger than the grasshopper's. Its body is smaller also. Therefore it can fly much better than the grasshopper. Does it fly as straight?

On the wings are thousands of tiny scales. These scales give the many beautiful colors to the wings. If you catch even the most gorgeous butterfly a little roughly and rub off

FIG. 88. Larva (caterpillar) and pupa (chrysalis) of butterfly

the scales, you destroy its beauty and its wings become dull and colorless.

Count the number of abdominal segments, and note the breathing spiracles as in the grasshopper.

Life History. The butterfly lays its eggs on the leaves of plants which will be good for the larvæ to eat. Where would you look for the eggs of the milk-weed butterfly? The larva is a long, hairy, worm-like animal called a caterpillar (căt-er pĭl'lar), which is generally the color of the leaves upon which it feeds. The caterpillar has two kinds of legs: a group of six legs in front representing the legs

of the insect, and several back, or false legs. Which segments of the caterpillar are without legs? In a short time the caterpillar quits eating and binds itself by a silken thread to a leaf or branch. This thread is somewhat like the thread of the spider's web, and comes from two little glands under the head. When the larva has bound itself up it becomes inactive and is called a chrysalis (krĭs'ă-lĭs). The chrysalis is much smaller than the caterpillar.

While in this stage, the pads for the wings grow larger, and the chrysalis begins to take the form of the butterfly. The skin then splits along the back and the young butterfly creeps out. When the wings grow strong enough, the butterfly flies away to its short happy life.*

Mĕt'amôr'phōsĭs The change that animals undergo in passing from the larval to the adult stage varies greatly with different animals. In the grasshopper, for example, the young is like the parent, excepting that it is very small and wingless. In the butterfly the young is entirely different from the adult. The marked changes that some animals go through in passing from the young to the parent form are known as its metamorphosis. If the change is slight, as in the grasshopper, the change is called an "incomplete metamorphosis"; if the transformation is great, as in the butterfly, the metamorphosis is complete. Is the metamorphosis of the house fly complete or incomplete?

* Experiment No. 5.

Collect a few cabbage leaves on which are butterfly eggs. Place them in a covered glass until they hatch. Keep fresh cabbage leaves in for food and note the active caterpillars. Watch for the attachment of the chrysalis and later for its molting and final unfolding of wings.

MOTHS

Some moths are often mistaken for butterflies. There are many kinds, however, and some of them look very little like the butterflies. One small, dull-colored moth lays its eggs in woolen cloth, in which the larvæ eat holes. Another kind, that flies about the papaya trees at night, has so large a body that it looks like a tiny humming-bird. Its wings make a humming noise, and it is therefore called the humming-bird moth.

Moths differ from butterflies in four distinct ways. First, the feelers, or antennæ, of the moth are more feathered, and have no knobs at the ends. Second, when at rest the wings of a moth are open. Third, the moth flies late in the evening or at night, but the butterfly flies in the daytime. The

FIG. 89. Moth in position of rest

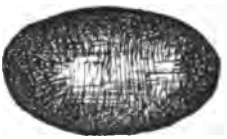


FIG. 90. Cocoon of silk worm

fourth and most important difference is that the larval form of the moth is a better silk-maker. In some, however, the silk can not be used because it can not be unwound. One kind of moth that lives principally in China, supplies us with almost all the silk that we use for thread and cloth.

You remember that the larva of the butterfly, when it is ready to change to a chrysalis, binds itself to a leaf or twig with a silken thread. This thread comes from two glands under the head. The glands make the fluid silk, which when it comes out into the air, hardens into tiny threads.

The silk-worm moth is gray. It lays its eggs on the leaves of the mulberry tree. The eggs become caterpillars that eat the mulberry leaves. This caterpillar grows to be two or three inches long and when grown it weaves a silken coat around its body. This coat is called a cocoon. When the cocoon is finished the larva, or caterpillar becomes inactive. It is now a pupa, or chrysalis. In a few weeks the chrysalis, if not destroyed, would cut through the cocoon to come out, and thus spoil the silk. So the chrysalis is killed with hot water and the silk of the cocoon is unwound and made into thread and cloth.

NOTE-BOOK

How do butterflies sometimes get their names?

Draw the head.

Describe the tongue of a butterfly.

What is the difference between the antennæ in the butterfly and the moth?

How many segments are there on the thorax?

To which segments are the legs and wings attached?

Give two reasons why a butterfly is a better flier than the grasshopper.

Compare the position of the wings of the butterfly and the moth at rest.

When and where is the best time and place to find butterflies? Moths?

Do you suppose the butterfly has air-sacs like the house fly?

The eggs of moths and butterflies are generally found on the under side of leaves. Why?

Name the stages in the development of the butterfly.

Compare the legs of the caterpillar with those of the parent in number; in position.

Is the body of the caterpillar divided into sections?

On which segments are the spiracles?

Describe the making of a cocoon.

From Experiment 5, write the life history, giving the time required for each stage of development.

What other animals go through a complete metamorphosis?

ANTS

Material needed: Some ants in a bottle.

Ants are among the most interesting of insects because of their habits. Sometimes thousands of the same kind, red, or black, or white, live together in the same colony or city. Often they have streets and cross streets connecting their houses, and sometimes they have special ants to keep order and to guard the colony from danger. Each colony, or community contains three kinds of ants: workers, a queen, and males. Some colonies have still another kind called soldiers.

The workers, Fig. 91, are the smallest kind. They can not fly for they have no wings. They are diligent and do not waste their time for they have much to do. When a

new nest is to be made they build it. They must supply the queen and males with food, and if they live in a cold country they must collect food for the winter time. Then when spring comes they must begin taking care of the eggs and little baby ants. Disturb an ants' nest and see the workers scurrying here and there carrying the eggs and young to a place of safety.

The queen ant, Fig. 92, has wings at first, and is much larger than the workers. She is cared for and guarded very

FIG. 91. Worker ant

FIG. 92. Queen

FIG. 93. Male

carefully by the workers. The queen sometimes lays as many as a million eggs. Generally there is one queen in the colony, but when the young queens are grown there are more.

The male, or father ant, is a very lazy fellow. He also has wings, like the queen, and is only a little smaller. Usually in each colony there are several males. But the workers get tired of feeding them and as soon as the queen has finished laying her eggs, the old males are killed at once.

Several kinds of ants also have soldiers. They are wingless, like the workers, and, in the white ants especially, are much larger. (See Fig. 97). They have very large, strong

jaws, and can quickly kill a common worker. The duty of a soldier is to guard the nest.

Ant Houses. You have seen ants going in and coming out of little hills thrown up of soft earth. These little hills are the doors to their houses. The real house is generally under ground. It is made of many little halls and rooms tunneled out of the earth. Sometimes it extends many feet from the entrance. The entrance hall is often dug straight down for about a foot, and the other rooms branch out from it. Some

FIG. 94. Diagram of underground nest: (A) hill; (B) upper room

FIG. 95. Worker of termite

rooms are used to store food in; others are used for the eggs and young ants. Fig. 94.

Some other ants make one room deep down in the earth and tunnel up, nearly to the top of the ground and here make another room. This is sometimes done in countries where there is a wet and a dry season. When it is very rainy the ants move to the upper room. Why? When it is very hot the workers carry the food and the baby ants all to the lower room. Which room is the cooler?

White Ants or Termites. All of the ants studied make their houses underground and enter them through little hills.

But the so-called white ants, which are not true ants at all, build large hills above the ground. Their hills are not the doors to their houses, but the houses themselves. Some of the ant-hills in the Philippine Islands are seven feet high and from twelve to fifteen feet around. These houses are also divided into separate rooms. The queen stays in the lowest room where she lays her eggs. The workers take the eggs to the upper rooms and place them in little cells which the ants make from wood-pulp.

The queen of the white ants, at egg-laying time, is from three to four inches long. In one of the termites of Africa the queen sometimes reaches the enormous length of six inches.

The workers are very different from those of common ants. They are white in color, and the body is thicker and heavier. The mouth parts are especially adapted for cutting into hard wood. Workers often tunnel out passageways in the floors or up the sides of the house, through which they can go unobserved. It is no uncommon thing in these islands to find the heavy timbers of a house hollowed out to a mere shell, and the house thus ruined and made dangerous to live in. From the wood eaten the workers form a kind of wood pulp from which they make the cells of their nests.

The jaws of the soldier, Fig. 97, are so large and heavy that it is unable to get its own food. The workers give it food and in return it protects the nest. If you put a worker on a small stick, on which there are several black ants, you will see him snap his big jaws at them as they touch him in passing.

Ant Slaves. Some ants are warlike. They form in battle line and march against their enemies. These battles are led by the soldiers. The victorious ants kill their enemies in the battle, and carry to their homes the food, the eggs, and the young ants that they have captured. We can easily see why they wish to take away the food, but what do they want with the eggs and the young? They take the best care of these

FIG. 97. Soldier

FIG. 98. Warriors

young ants and train them to be their slaves. That is why we may sometimes find two kinds of ants in the same colony.

The slaves get food for their masters, help in building the houses, and care for the young. They do not return to their own homes, but seem contented to work in the new colony.

But ants are somewhat like men. If men have slaves to do their work, they themselves forget how to work and grow so dependent that they can not live without the slaves. A naturalist tried some interesting experiments with warrior

ants and their slaves. He shut up some warriors and their larvæ without a slave but with plenty of food. The ants neglected their larvæ. They could not even feed themselves and many of them died. He then put one slave with them. The slave went to work and saved the larvæ and the remaining warriors from death.

Food. Ants like to eat anything that is sweet. Some ants

Fig. 99. Ant-cow

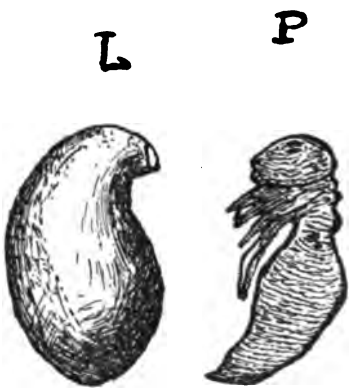


Fig. 100. Larva and pupa of ant

are so greedy that they will eat sugar or honey until they can hardly walk. Sometimes you will see two or three ants carrying home an insect that they have found. If an ant finds foods that is too large or heavy for it to carry, it goes and gets other ants to help it.

Ant-Cows. Ants are queer little animals in several respects. One of the queerest things about them is that they have cows. The ant-cow is a little green insect that lives on green leaves. Its true name is Aphis (ā′fis). The colony of ants may have many of these cows (ăphīdēs, plural). When the aphides are young the ants collect them and care for them until they

are old enough to be useful. When the ants want milk they climb the plants where the aphides are feeding and rub the little cows with their feelers. The aphides give off a sweet juice from their bodies that the ants like very much.

Life History. When the young ants in the nest are grown, the winged males and females fly away and pair. The queens then lose or tear off their wings, and with workers, form new nests. Each queen, when she goes to a new nest, is given a special room where she lays her eggs. The workers carry the eggs away, put them into the little rooms and halls of the nest, and take good care of them. When the young hatch they must be kept from getting too warm or too cold. When they are too cold they take them out into the sunshine. In a week or more the larvæ become pupæ. A very strange thing is the way in which the workers make queens and males out of the larvæ and pupæ. They feed them the choicest food and soon they grow into the larger and more handsome queens and males.

NOTE-BOOK

Why do we say that the ants are among the most interesting of insects?

How many kinds are found in each colony? Describe each and tell the work done by each kind.

What kind of houses do ants build? How do they make a cool room and a warm room?

Why do some ants have wars?

Tell about ant slaves. How are slave-holding ants like men?

How did one scientist prove that warriors forget how to feed themselves?

If you give an ant a large piece of food that it can not carry what will it do?

What are the ant-cows; and of what use are they to ants?

Which is the more clearly divided into segments, the worker of the common or the white ants. How do they differ?

Which ant is the most destructive to property? To other ants?

Why are termites not rightly called ants? See page 131.

When the eggs hatch what is done with them? How do the queens and males differ from the workers in the young state?

Describe briefly what you have seen.

EXCURSION:

An excellent exercise for the class is to saw, or cut through, a large termites' hill and remove half of it so that the other half may be sketched and the eggs, larvæ, pupæ, workers, soldiers, males, and queen studied. The queen's room is at the bottom and near the center of the hill. Note also the wood pulp with which the workers form the rooms and halls.

INSECT-LIKE ANIMALS *

THE SPIDER

Material needed: Sometimes a spider's web may be found on a twig and the twig cut and brought in without disturbing either the web or the spider.

The body of the spider is divided into only two parts:

* Animals of this type belong to the class Arachnida.

head body and abdomen, or back body. We shall find that the spider lacks many of the characteristics common to insects.

The spider has no true feelers, or antennæ, although it has feeler-like organs called labial palps, with which it brings food to its mouth. What are the antennæ generally used for? It has no compound eyes, but above the mouth are usually eight simple eyes.

The mouth has two large fangs. When the spider captures

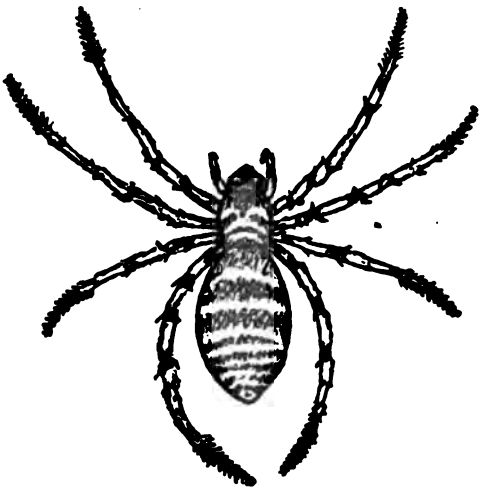


FIG. 101. Spider

any kind of insect it kills it with a thin liquid poison which is sent through these fangs. This poison is sufficiently strong to kill an insect, but it does not do the spider any harm. Some kinds of spiders are poisonous to man as well as to insects, and we call the fangs of these "poison fangs." What other animal kills its prey by poison?

One of the ways in which a spider is different from insects proper is that it has no wings.

How do the legs of the spider compare in number with the legs of a fly. The spider has eight jointed legs. The front pair is used as feelers and the hind pair, as we shall see later, in making the web. The legs are jointed to the head body.

Under the abdomen are two peculiar kinds of organs. One kind is called the spinnerets. Inside of the back body,

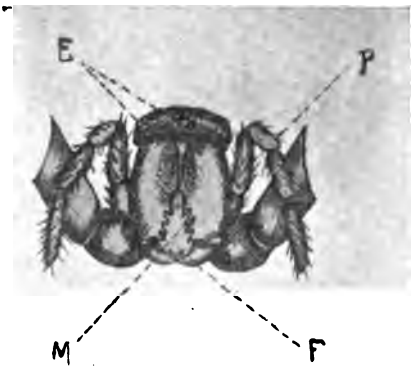


FIG. 102. Head of spider: (E) eyes; (F) fangs; (M) mouth; (P) labial palps

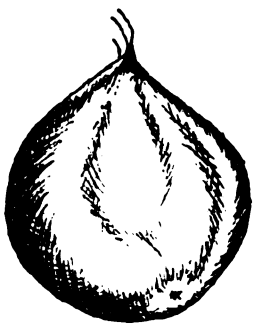


FIG. 103. Ball of spider's eggs

close to the spinnerets, are glands that make a clear fluid. The spinnerets are the little tubes that let this fluid out. When the spider wants to make a house and has selected a good place, it pushes the spinnerets against the surface where it wishes to begin, and a little of the fluid is forced out. This fluid sticks like glue. As soon as the fluid is fastened the hind feet begin to pull it out. The fluid comes from the spinnerets and is hardened by the air into a thread. With these threads, the spider makes a delicate web.

The other organs under the abdomen are the breathing

spiracles. These spiracles are different from the breathing holes of the insects that we have studied. They are crescent-shaped in the spider. What is the difference in the position?

The spider generally has two lungs, as we have, but they are very simple. Air enters the lungs through the spiracles.

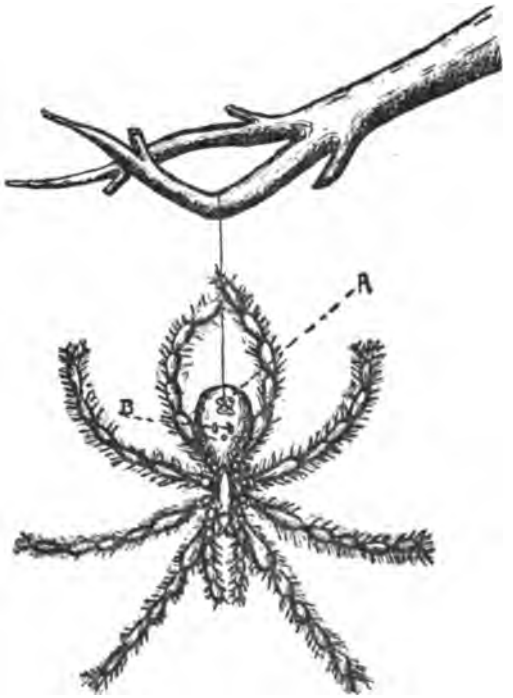


FIG. 104. Spider beginning web: (A) spinnerets; (B) spiracles

The heart is tube-shaped. The blood contains no red blood cells, so it is white.

The spider is very fond of flies. As soon as an insect of any kind gets caught in the web, the spider runs out to see what it is. If it is a fly or anything that can not sting or bite, it is brought in, but if it is an insect that the spider

is afraid of, a web is woven around it. Soon the insect's wings are bound down so that it can not move and it soon dies. When it is dead the spider either eats the soft parts of the body, or puts the insect away until it is hungry.

Life History. Spiders are different from most insects in development. The female lays many eggs and usually binds a web around them so that they look like a little ball. In some the eggs are carried around with the mother in a large flat case. In a few weeks the eggs hatch into young like the adult form. At first thousands of these little spiders live together inside of the web-covered ball or case. When they get too large to live in the ball, they come out and live on plants. The wasps like to catch them while they are at this age as food for their young, and if nature did not protect the young spiders by making them the color of the leaves on which they live, few of them would ever reach full size.

NOTE-BOOK

Compare the spider with the grasshopper in number of sections.

Describe the eyes.

What are the fangs used for? How do they differ from the snake's fangs?

Draw the head of the spider, showing (a) the feeler-like organs, (b) the eyes, (c) the poison fangs, and (d) the mouth.

How many legs has the spider? Which ones are used in making the web? What is the use of the front legs? To what part of the body are the legs attached?

Describe the spinnerets.

Tell how the spider makes its house.

What do the spiracles of the spider look like?

Describe the lungs and heart.

Why is the blood white?

Tell how the spider captures its food.

How are its eggs protected? What form are the young?

How do plants protect young spiders?

Is its development more like that of the grasshopper or butterfly?

Observation: Open a ball of spider's eggs in a glass to see the young.

SCORPIONS

The scorpion (skor'pĭ-on) is like the spider in being divided into only two regions; but the body is longer and more like that of the crayfish (krā'fĭsh), one of the crustaceans next to be studied.

This animal is clearly segmented, there being eighteen segments in all.

The head body is covered by a single plate bearing from six to ten eyes. The labial palps are developed into pincers, with which the prey is seized. Like the spider there are four pairs of walking legs.

The abdomen is divided into two parts. Count the segments in each. The front part is larger than the terminal part, the tail. Along the sides, and somewhat underneath, are the slit-shaped spiracles, from the third to the sixth abdominal segments.

At the end of the tail is a pointed sting. In a scorpion the

sting is different from that found in insects such as bees and wasps, but it is capable of causing a great deal of pain. If you should see a scorpion catch an insect, you would see it

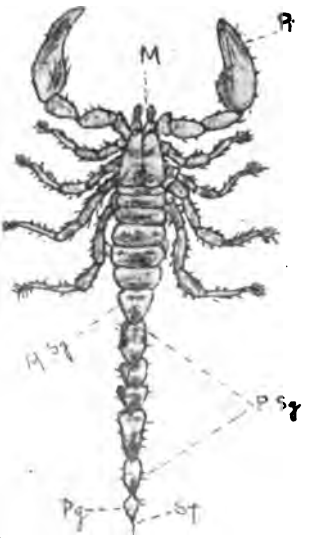


FIG. 105. Scorpion: (A Sg) anterior abdominal segment; (M) mouth; (Pg) poison gland; (Pi) pincer; (P Sg) posterior abdominal segment; (St) sting

thrust its tail suddenly forward over its back and sting the insect to death.

Inside of Pg. Fig. 105 there are two poison glands connected with the sting and it is the poisonous fluid from these that causes the pain. Some of the larger ones, which are five to six inches long, cause great suffering even in man but it is doubtful if the poison ever causes his death.

Habits. Scorpions are inhabitants of warm countries. They live in crevices and holes during the daytime, coming out at night to find food.

Digestion. Under the anterior part of the body is the narrow mouth. The esophagus is wide and may be dilated in sucking out the juices from the insects captured.

Breathing Sacs and Heart. Connected with the spiracles are breathing sacs. Each one of these looks something like the cavity inside of a lot of washers piled upon each other. Its lining is very thin and contains many tiny blood vessels that take the oxygen from the air.

The heart extends the entire length of the anterior part of the abdomen and is divided by partitions into one more room than this part of the abdomen has segments.

The sense of touch is well developed. The lateral eyes at the sides of the head body are similar to the simple eyes in insects, but the large middle eyes are more like groups of simple eyes than compound eyes.

Development. Unlike true insects the young scorpions are born alive. It is an odd sight to see the mother carrying them around attached by their pincers to different parts of her body.

CHARACTERISTICS OF INSECTS

1. Insects have no backbone and are called invertebrates.

2. All insects have the body divided into sections. Usually there are three sections: head, thorax, and abdomen. What insect-like forms that we have studied have not the three parts?

3. Insects have six legs that are attached to the thorax. Most of them are winged. Some have four wings, some two, and others, for example the fleas, are wingless.

4. They generally have two compound eyes that are divided into many facets. Tell which insects have also simple eyes.

5. Insects do not breathe through the nostrils or mouth but through spiracles in the abdomen.

6. The life history usually has three stages after the egg: larva, pupa, and the imago (īmā'go) or parent form. Where do the different insects that we have studied lay their eggs? Make a list of the forms studied and tell which have complete metamorphosis, and which incomplete. What is the larva of the mosquito called? Of the house fly? Of the moth? Of the dragon-fly? A pupa usually spends its time in an inactive state without eating. What one remains active?

7. Which insects that we have studied have all six of these characteristics? Which have so few as not to be classed as true insects?

2. CRUSTACEANS (CLASS CRUSTACEA)

THE CRAB

Material needed: (1) Living crabs in sea water. (2) Land crabs. (3) From the beach get a few hermit crabs.

Crabs * are of many interesting forms and of various sizes.

* Crabs, like insects, have the appendages of the body (antennæ, legs, etc.) jointed. But the body, instead of being covered with chitin, is protected by a strong, lime-like crust. Because of this crusty covering animals of this order are called crustaceans (krŭs tā'sheans).

The tiny oyster crab is so small that it can live inside of the shell with the oyster. The spider crab found off the eastern coast of Japan sometimes grows to be twenty feet across from tip to tip of claws.

The body of the crab, like that of the spider, is divided into two parts: a head body, and abdomen, or back body.

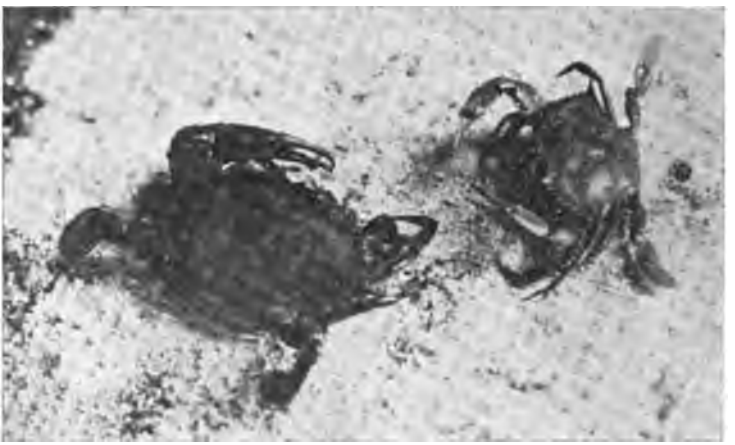


FIG. 106. Edible crab

The head body is broad and shield-like. The back body is poorly developed and is doubled under the head body. Both the head body and the back body are segmented, although the segments in the former are difficult to see. Each segment has a pair of limbs or appendages.

The hard external skeleton of lime-like substance serves to protect the soft internal parts. There is no jointed internal skeleton, but as you have probably noticed there are unjoined cartilages inside of the appendages. Name an animal that has both an external and an internal skeleton. Usually an

external skeleton is so heavy that it makes the animal clumsy. We can not say that the heavy skeleton makes the animal stronger, but that it is a protection to it.

Sometimes crabs have a soft shell or skeleton. That means that the shell, or old cover, has been recently shed and that

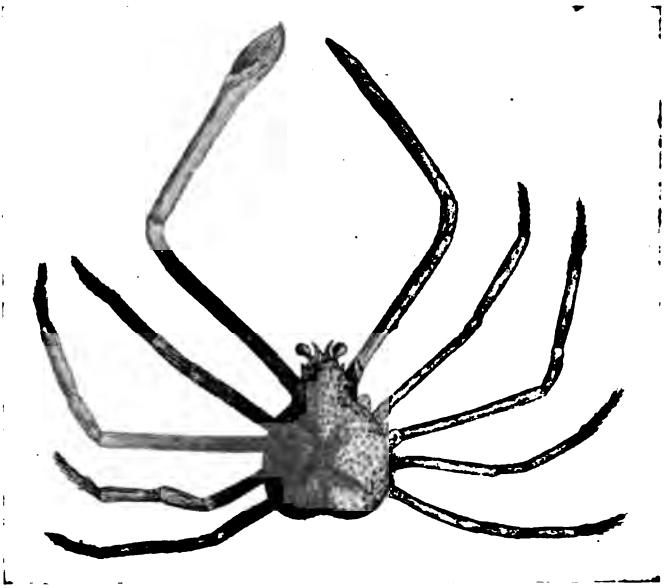


FIG. 107. Spider crab. Measuring about 10 feet from tip to tip of claws (Cebu High School)

the soft one is new. When a crab or a lobster gets ready to molt it crawls away to a place that is quiet. Then the shell breaks at the base of the tail and the animal wriggles out. Its life is now in great danger, but soon the outside skeleton forms and the animal goes back to its old home.

Crabs can run in any direction, forward, sidewise, or backward equally well. The different legs serve different purposes. At the end of the first pair are two big toothed claws

or chelæ (kē'lē). These claws are used not only in catching and crushing food, but also in defense. In the Fiddler crab one of these claws is much longer than the other and looks as if the crab were playing the fiddle, or violin. The end of the fifth leg in swimming crabs is paddle-like. The pointed feet are of most use in walking. Under the abdomen (back body) are several pairs of appendages called swimmerets (swĭm'mer-ĕts). Count them. They look to be useless, but

FIG. 108. Fiddler

FIG. 109. Young crab

in the study of the life history we shall see that they have a purpose.

On the head of the crab you can see two pairs of feelers. The first pair is often bent at the end; these are called antennules (antĕn'nūles), the second pair, the antennæ. At the base of the antennæ are the ear sacs. Near the feelers are two eyes that stand out from the head and can turn in any direction. Because the eyes are at the end of stalks they are said to be stalked eyes. The eyes have no lids and are compound; that is, each eye is made of many facets.

The mouth of the crab is made not only of one pair of

jaws, but of several. Do they move sideways or up and down in eating? The gullet, or esophagus, leads from the mouth to the stomach. The stomach has muscular walls that are lined with teeth. Food that enters the stomach is soon ground fine enough to be absorbed by the white blood. How does the blood of the crab compare with that of reptiles?

Crabs that spend their lives in the water breathe by a simple gill arrangement.

The nervous system is well developed in both the crustaceans and the insects, but instead of the nerve cord running within the cavity of the backbone as in vertebrates, it runs along the ventral, or lower part of the body. Also instead of being a single cord like the spinal cord of vertebrates, it is usually double and looks somewhat like a ladder.

Life History. The eggs of the crab are fastened to the swimmerets of the mother with a kind of glue. The young hatch in a couple of weeks and instead of leaving the parent they hold on to the swimmerets until they are big enough to take care of themselves. Note the difference in looks between the young and the adult forms.

THE HERMIT CRAB

A crab that differs somewhat from the common crab is the hermit. This crab may be seen on the beach crawling around inside of various kinds of univalve shells. It has no shell of its own to protect its back body, so it hunts around until it finds one that suits it. If the shell is uninhabited the hermit puts its unprotected back body in and seems quite proud of its new home, but if its chosen shell has some other

animal living in it the crab immediately proceeds to get rid of the inhabitant.

Sometimes the hermit further protects itself by allowing a sea anemone, ~~somewhat like~~ (Fig. ~~110~~ 432) to grow upon its back.

FIG. 110. Hermit (Jordon and Heath)

It then looks like a plant and its enemies pass it by without noticing it.

Shrimp, lobsters, and crayfish also belong to the order crustacea.

NOTE-BOOK

How does the spider crab get its name?

In what are crustaceans and insects alike?

Describe the outside shell and tell how it differs from that of insects.

Has the crab anything like an inside skeleton?

How does the external skeleton protect an animal?

Into how many general divisions is the body divided?

Draw a large claw, or chela.

Give the number, use, and attachment of the legs.

Where are the other appendages, such as the antennæ and swimmerets borne?

Are the segments of the head body as distinctly marked as in the insects? How many appendages grow from each segment?

How many segments has the abdomen? In what way is it protected?

Describe the Fiddler.

Locate the ear of the crab.

What is meant by "stalked-eyes"?

Tell about the stomach of the crab.

Compare the blood of the crab with that of the monkey.

How and why does the mother carry her eggs around with her?

SECTION V

MOLLUSKS (CLASS MOLLUSCA)

UNIVALVES

Material needed: (1) Pond snails (found on sticks in ponds); (2) Land snails (found under old logs); (3) A number of small marine univalves (got from the beach and kept in a glass of sea water); (4) Empty univalve shells of various types.

Animals with shells formed of a single piece are called univalves (ū'ni-vălves). Univalves are of three general types: marine, fresh water, and land forms, any of which make good types for study. The marine univalves creep along the bottom or burrow in rocks. They outnumber both the land and fresh-water forms. Fresh-water forms may be had by pulling up sticks on which they are found in ponds. Land snails are abundant under stones and old logs.

A walk along the beach just after high tide will show a multitude of marine univalves. Upon taking up some of these mollusks (mŏl'lusks) you will notice that the animal withdraws into its shell. Why? The opening into which it withdraws is the mouth of the shell. This is sufficiently large for this mollusk to go in and come out, yet the animal never leaves its shell completely. In gill-breathing forms there is a lid that closes the mouth. Look for this on the foot. The outer edge of the shell around the mouth is the

outer lip. Fig. 111 (Ol). The large, smooth, inside border is the inner lip (Il).

The sharp point of the shell opposite the mouth is known as the apex (ā'pex). This tiny point was the shell of the univalve when it was very little. The shell is usually of a spiral or screw shape. The spiral is made up of a number of turns called whorls. The whorls taken together form a

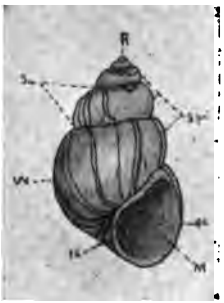


FIG. 111. Snail shell: (A) apex; (Il) inner lip; (M) mouth or aperture of shell; (Ol) outer lip; (Su) suture; (Spi) spire; (W) whorl (Morse)

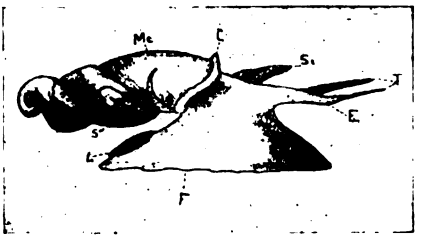


FIG. 112. Body of Triton out of shell: (C) collar of mantle; (E) eye; (F) foot; (L) lid to aperture; (Mc) mantle cavity; (S) stomach; (Si) siphon; (T) tentacle (From Parker and Haswell)

spire. In a grown snail there are usually four or five whorls to the spire. Turn the shell with the sharp point or apex toward you. Do the whorls turn to the right or to the left? If they turn to the right it is known as a right-hand shell; if to the left, left-hand. Another way of distinguishing a right from a left-hand shell is by placing the apex upward and the mouth toward you as in Fig. 111: If the outer lip is to the right it is right-hand, if to the left the shell is a left-hand shell.

Observe an animal that has remained quietly in a glass

for some time. It will be noticed that the head and the foot protrude from the aperture. The hinder, or posterior, body part joined to the shell by a muscle is also screw-shaped to fit the shell and remains attached to it throughout life.

The greater part projecting from the shell is the foot, a tongue-like muscular organ. Watch the animal creeping up the side of a glass to see the movement of the foot. Glands in the foot secrete a sticky slime which makes it hold to smooth surfaces. In some the glands secrete a thread like a spider's thread, by which the animal can suspend itself in the water.

In land snails the head is raised up somewhat in moving. In this form there are two pairs of tentacles. At the end of the longer pair are the eyes. Touch the tentacles with a pencil to find out their use. In others, for example in the large triton (trī'ton), a marine form, the eyes are borne at the middle of a long pair of tentacles, Fig. 112. The short lower tentacles are wanting in many univalves, and in these the eyes are located at the base of the long tentacles. (Pond snails.)

At the front (anterior) end of the body is the mouth. It may be possible for you to see its movement while the animal is eating along the side of the glass. It is provided with a long ribbon-like tongue which is covered with rows of tiny teeth. In some there are as many as forty thousand teeth. The long toothed tongue moves backward and forward over a pulley-like organ in the floor of the mouth. By this movement the teeth act like a rasp in cutting the food into small bits.

Feed a land snail fresh cabbage leaves in the glass, then look for the prints of these teeth on the leaves.

Respiration. Univalves breathe either by lungs or by gills. The common pond snail may be seen to come to the surface of the water at times to breathe. The spiracle, or breathing hole, is at the edge of the lip and may be seen to close just before the animal goes down after breathing. In this kind of snail there is a single lung formed of the mantle. In marine forms there are usually simple gills that look a little like a feather with a single vein.

Development. In the bottom, or on the sides of the glass, where the pond snail has been kept for some time, long gelatinous egg-capsules from one-half to an inch in length may be seen. These are so clear, however, that they are not easy to find. If you look at one of these capsules with a lens you will see that it contains from thirty to fifty eggs, embedded in a jelly-like material. Each egg is enclosed in a shell, and contains food for the young. In warm places the egg soon develops. But the changes that it undergoes in developing from a single cell to a many celled, living thing are too difficult to understand until later in your study of animals. The tiny animal is unlike its parents. Soon its little shell, which is the tip end (apex) of the large shell, forms. The body inside of the shell at first is not twisted. As it grows older, however, it becomes spiral shaped. As fast as the animal grows, its mantle adds little by little to the shell. The first whorl formed is so thin that the beating heart can be seen through it; then another and another whorl is made until at

last the animal is mature. It then lays its eggs and its "life cycle" is complete.

NOTE-BOOK

Into what general types may univalved mollusks be divided?

What is the use of the shell? How is it carried?

Draw the shell, lettering its different parts.

What is the apex?

Count the whorls on some of the shells and find whether or not the animal was grown.

Give two ways of detecting a right from a left-hand shell.

If you place a shell by the side of a screw do the whorls run in the same or in the opposite direction to the threads of the screw?

How has the shape of the body been changed by the shell?

How do univalves differ in tentacles? Eyes?

What is the peculiarity of the teeth, and how are they used?

How does a land snail breathe? A marine form?

Give the points in the development of a pond snail.

What does "life cycle" mean?

BIVALVES

Material needed: (1) Living bivalves kept in a vessel of water, having about two inches of sand in the bottom; (2) shells both of mussels and oysters.

The Mussel. Animals of this type are inclosed in a strong shell made of a kind of lime. Each shell is formed of two

halves, or valves. Because of this the animal is called a bivalve (bī′vălve). At the back, the valves are held together by a hinge. Press the valves of an empty shell together and note the use of the hinge.

Bivalves vary in size from tiny things to those weighing as much as five hundred pounds.

If you put a mussel in water containing sand, as suggested, after everything has become quiet you will see it raise itself up

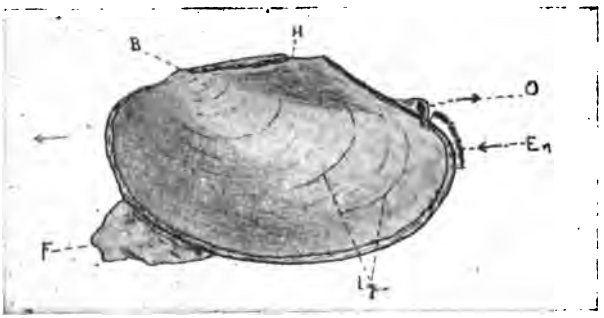


FIG. 113. Mussel: (B) beak, or umbo; (En) siphon for entering current; (F) foot; (H) hinge of valves; (Lg) lines of growth; (O) outgoing siphon (Parker and Haswell, after Howes)

from its side and move slowly along on the edge of its shell. Place one of the mussels on a plate of glass to see whether or not it can move as in the sand. Note that in moving in the sand (1) the thick edge of the shell, or the hinge, is up; (2) the thin edge of the closed shell is now down and partly opened; (3) the blunt end is the front (anterior), (4) the thin end the back (posterior) end of the shell. From this you can easily determine the right and left valves of a shell, by holding the hinge upward and the blunt end (front end) away from you. The right valve will be to your right side

and the left to your left. Learn to distinguish right from left valves in all the shells found.

On the outside of the shell there are lines or markings around the shell almost parallel to each other. These are the lines of growth (Lg). You will notice that the lines of growth get smaller and smaller toward the front part of the hinge to a point (B.) the beak, or umbo. The beak is the oldest part of the shell and corresponds to the apex in univalve shells. It was this part that was the first shell of the tiny mussel before it grew large. As the mussel grew larger and larger the shell also grew to protect the animal within it.

At the thin back end (posterior) Fig. 113, note two tubes —an upper and a lower one—known as siphons (sī'fons). The upper siphon (O) is smaller and more nearly round than the lower one which is fringed with tentacles. A current of water passes in at the lower siphon and out at the upper, as is shown by the direction of the arrows. In some mussels only the upper tubular siphon is present. In other bivalves, for example the oyster, there are no siphons.

Directed forward in the moving mussel is a single tongue-like foot (F), with which the animal slowly drags itself along. In the oyster and other bivalves which remain attached to rocks throughout life, no foot is present. Near the back part of the foot in some of the sea mussels there is a gland which secretes silk-like threads for the temporary attachment of the animal. Located in the foot also is the ear, or organ of hearing.

On the smooth inside of the empty shell at both the front

and back ends, notice the rough places, or scars. The two large ones are for the attachment of the muscles that close the shell. (The oyster has but one.) Try to open a live mussel and see how tightly it holds. If we place the animal in hot water it will soon open. In a bivalve thus opened note the strong muscles themselves.

Some one has well compared a mussel to a book partly opened. If you will hold this book with its back in the same position as the hinge in the moving mussel, that is upward, the hinge of the mussel will represent the back of the book; the two valves the covers; a thin mantle lobe on each side the single fly-leaf in the front and back; the two gills on each side the first two and last two pages containing printing; and the foot the remainder of the leaves, inside of the book.

We have already studied the hinge and the valves which represent the back and the covers of the book. Let us now look closely at the living part of the mussel inside of the shell, keeping in mind our comparison with a book to make it clearer.

The Mantle Lobes. Like the fly-leaves of a book, just inside of each valve is a single thin layer of membrane called the mantle lobe. These two lobes, one on each side, serve not only as a lining for the valves but also as a soft outer covering for the living animal. The lobes of the mantle are attached to the shell above, near the hinge, as fly-leaves are attached to the back of a book. Around the lower edge of the shell the lobes are also attached. It is at this place of attachment that the mantle secretes new lime-like material

which it adds to the thin edge of the shell to make it larger. But this is not the only important thing that the mantle does. It lines the entire inside of the shell with a pearly layer of nacre (nā'ker) or "mother of pearl," making it smooth and beautifully colored.

At the posterior end of the animal the mantle may be seen projecting from the shell to form the siphons. The right and left mantle lobes unite completely to form the upper siphon, but they do not grow quite together around the lower one.

The space between the two mantle lobes is known as the mantle cavity.

This cavity incloses the gills which correspond to the first two and last two printed pages, and the foot, digestive tract, etc., which represent the other middle pages of our book.

The Gills. Just inside of the mantle lobes are the gills —two on each side—see Fig. 114. These are attached above but are free below and resemble sieve-like sacs hanging between the upper and lower siphons in the mantle cavity. Compare their attachment with that of the mantle lobes. Cilia (plural of cilium) on the gills and at the entrance of the lower siphon cause a current of water to enter by the lower siphon. This passes into the mantle cavity, through the gills, giving them oxygen, and finally out at the upper siphon (O).*

* EXPERIMENT No. 6.

With your mouth draw some ink into a small glass tube, or tube of bamboo, about a foot long. Keep your thumb over the upper end of the tube to keep the ink from running out. Place the free end of the tube in the water near the siphons of a moving mussel and let a few drops of the ink out near the siphons to see the direction of the current.

Digestion. Cilia on the labial palps, Fig. 114 (P) cause a part of the water entering the lower siphon at (En) to pass forward to the mouth instead of first going through the gills. Minute animals and plants in the water are directed by the palps to the big mouth (M), just above the foot.

The mouth opens through a short esophagus into the stomach (S), above which is a large liver (L), that forms a secretion used in digestion. The long intestine curves from the stomach downward, then upward and backward, carrying waste material into the outgoing current.

FIG. 114. Diagram of mussel with left mantle lobe mostly removed: (– – –) digestive tract; (A) opening from digestive tract; (E) esophagus; (En) entering siphon; (F) foot; (H) heart; (I) intestine; (L) liver; (Lig) left inner gill; (Log) left outer gill; (M) mouth; (Me) muscles; (O) out-going siphon; (P) labial palp; (S) stomach

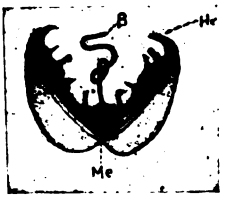


FIG. 115. Young mussel: (B) thread for attachment; (Hk) hook; (Me) muscle (From Korschelt and Heider's Embryology)

Circulation. Directly under the hinge of the shell is the three-roomed heart. The transparent blood carries the oxygen got in the gills and the nourishment from the digestive tract to all parts of the body.

Rē'prōdūc'tion. Sometimes one may find the outer gills large and swollen. Hundreds of eggs or young collect in

the cavity of the gills where they are carried around by the mother and nourished by the incoming current of water. When first hatched the young mussel is very small and does not look much like the parent forms. Although it has two valves, yet the valves are not closed and are provided at the tips with hooks, Fig. 115 (Hk), with which the young are helped to cling, as parasites, to fishes and crabs. At this stage they live from the substance of the animals to which they are attached. Finally they settle to the bottom and begin life for themselves. The tiny shell of the young represents the part of the old shell called the beak or umbo, Fig. 113 (B). From the lines of growth you can see that the shell was very small at first, but as time passes it grows larger and thicker adding new lines of growth one by one. After a period of five to seven years full size is reached.

PEARL FISHERIES

We learned that the mantle forms the pearly layer inside of the shell. If a grain of sand gets between the shell and the mantle the mantle forms layers of pearl over it and thus a pearl is produced. Both the pearl-oyster and the pearl-mussel form pearls.

The pearl-fisheries off the coast of Ceylon have been known for more than two thousand years. In recent years some valuable pearls have been obtained in these islands. In order for pearl-fisheries to be of greatest value, the oysters or mussels must be carefully cared for and protected, otherwise they will be killed out by starfishes or by the mud and slime of the ocean bed.

NOTE-BOOK

Why is an animal of this order called a bivalve?

How does the mussel differ from the snail in protecting itself?

By what way can we distinguish the front (anterior) from the back (posterior) part of the shell? The right valve from the left?

From the number of lines of growth is it probable that a line is added each year?

What is the reason the beak, or umbo, is the thickest part of the shell?

Give two reasons why the shell in the dead mussel gapes open.

Account for the smoothness of the inside of the shell; the rough places.

Why is the mantle so important?

Passing from the shell outside to the center of the animal name the layers in order.

Compare the mussel with a book.

How many gills are there? What is their position with relation to the siphons?

How is the water current produced? Give its course and its double use.

In what ways have the habits of the oyster made it different from the common mussel?

Describe briefly the parasitic life of the young.

How are pearls produced? How obtained?

THE SQUID OR ARROWFISH

Material needed: A squid to see movements and color.

The squids (skwĭds) are highly developed mollusks which travel in schools, like fish. Instead of creeping sluggishly along the bottom like univalves and bivalves they dart through the water with great rapidity. They are often called "sea arrows" by sailors because of their habit of leaping out of the water. Some kinds have been known to leap so high as to fall on the decks of passing vessels.

Squids vary in length from an inch or two, to by far the largest in the invertebrates, the giant squid being from forty to fifty feet long.*

The body is divided into a head, a short neck and a trunk.

The head bears two immense eyes that are nearly as highly developed as the eyes of a vertebrate. Surrounding the mouth is a circle of ten arms provided with suckers for holding prey. Eight of these arms are thick and strong at the base, tapering to a fine stiff point, resembling somewhat the leaves of the maguey plant. Each of the eight arms has two rows of suckers. Two of the arms, the tentacles (tĕn'tăcles), are much longer than the others and are capable of being drawn partly into sheathes at their base. The tentacles are round and club-shaped, and bear four rows of suckers at their enlarged ends.

The trunk in some is broader than the head and has wide

* One of these in the Field Columbian Museum, Chicago, is forty and one-half feet from the posterior part of the body to the tip of the tentacles, with a body length of nine feet.

muscular fins extending from the sides. In others the body is slender and the fin is developed into an arrow-point at the posterior end. Because of the shape of the tail-fin the squid is often called an arrow-fish. In some of the largest of squids this fin is as much as twenty-two inches in length and is of great use in movement. The front (anterior) end of the trunk runs forward considerably and serves as a kind of protection for the head to be drawn back under. The trunk is inclosed in a tough sac, the mantle, which secretes a kind of internal shell called the pen. The pen lies along the back just under the skin and serves both as a protection for the body and as an attachment for the fin muscles. Sometimes the pen may be found along the beach at low tide. It looks a little like cuttlefish bone—the internal skeleton of the cuttlefish—often seen in bird cages. The two are very different, however, in composition. The cuttlefish bone is made of a lime-like, or chalky, material while the pen of the squid is horny.

Inside of the body and inclosed by the mantle, as in bivalves, is the mantle cavity in which the organs of respiration and digestion are located.

The gills—two in number—are shaped somewhat like a large feather or plume. How do they compare in number with the gills of the mussel? They get oxygen from the water that passes in and out of the mantle cavity.

Food and Digestion. In their feeding habits squids often move along the bottom with the arms and tentacles downward and the body extending upward. Their food consists of animal life and is caught and carried to the mouth by the ten-

tacles. Inside of the mouth are two cartilaginous jaws that look a little like the beak of a parrot. The narrow esophagus is long and leads to the stomach. The short intestine carries waste material to the mantle cavity from which it is thrown out through the siphon, as we shall see later.

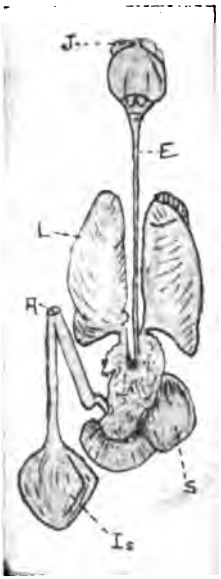


FIG. 117. Digestive tract of a cuttle-fish: (A) opening from intestine; (E) esophagus; (Is) ink sac; (J) jaws; (L) lung; (S) stomach (From Cambridge Natural History)

Movement. Pointing forward under the neck and head is a large tube, leading from the mantle cavity. This is the outgoing funnel or siphon carrying water and waste material from the mantle cavity. The water enters the mantle

cavity through a slit between the lower edge of the mantle and the siphon. This slit can be closed and by quick contractions of the walls of the mantles, jets of water are forced out through the funnel sending the animal rapidly backwards. Do the siphons aid in movement in the mussel?

Animals of this type have a strange way of escaping their enemies. Fig. 117 (Is) shows a large pear-shaped sac, the ink sac. Inside of this a kind of ink is made. When the animal is alarmed a quantity of this ink is thrown into the mantle cavity, from which it is thrown through the funnel into the water. While thus protected by the black cloud of ink in the water the squid darts suddenly backward and escapes unnoticed.

Development. The eggs of squids are usually found about May or June. They are deposited in jelly-like radiating sheaths about four inches long, which are called "sea mops" by sailors because of their peculiar shape. Sometimes thousands of young squids are hatched from the eggs of a single female. They resemble the parent from the first, so go through no metamorphosis.

NOTE-BOOK

Draw the squid.

Name three ways in which it is one of the highest mollusks.

Compare the eyes of the higher mollusks with those in bivalves.

In how many ways do the arms and tentacles differ?

What is the use of the suckers?

Describe the part of the body that makes the squid arrow-shaped.

Compare the shell with that of the mussel; the use of the siphon.

How do the gills differ from those of univalves?

Explain the movement of a squid. Can it move forward?

In how many ways does the getting of food differ from that of the mussel?

How is waste material from the digestive tract thrown off?

Write a short description of how a squid protects itself.

Describe briefly the life history.

THE OCTOPUS OR DEVIL-FISH

Material needed: A small octopus got from the market or from a fisherman to study its movement and way of escaping when disturbed.

Another mollusk known for its great size and strength is the devil-fish. In darting through the water it is similar to the squid; both move backwards by means of siphons, Fig. 118 (Si). The octopus (ŏk'to-pus) or devil-fish, however, is also able to creep about on its tentacles in search of food and differs from the squid in several important respects. While the latter travel in great numbers, it is solitary. Most of the higher mollusks have a strong internal skeleton for the attachment of muscles. This form has neither an outside nor an inside skeleton or shell. At rest the eye is directed upward, and the body is folded downward, Fig. 118 (A). In the devil-fish the eye can be covered with a fold of skin.

The principal distinction between the two types, however, is suggested by the word octopus itself (*octo,* eight; and *pous,* a foot).

Fabulous stories are related of the habits of this mollusk and of its tremendous strength. We are told of how it attacks and upsets small boats, or of how one may silently reach into

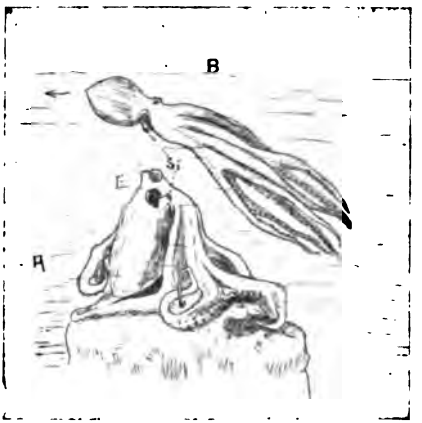


FIG. 118. Octopus or Devilfish (A) at rest; (B) moving; (E) eye; (Si) siphon (From Parker and Howell)

a boat with its long, snaky tentacles and drag a sailor overboard to his death. Of course these stories are untrue, for the octopus is timid in nature, yet if it is disturbed it is one of the most powerful of mollusca. Some of the large ones reach the length of twenty-eight feet across from tip to tip of tentacles.

The great strength comes not from the body, which is small, but from the powerful tentacles themselves and their suckers. Under each tentacle are rows of suckers or disks something like those of squids but different in that they are

not stalked and are more numerous, giving them tremendous holding power. At the base of the tentacles the suckers are large and grow smaller and smaller toward the end where they are entirely absent. In shape they are round and have lips of cartilage. See Fig. 119.*

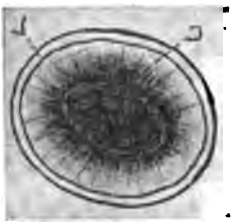


FIG. 119. Diagram of sucker: (C) central part; (L) lip

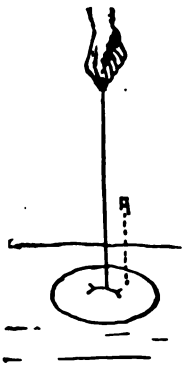


FIG. 120. Showing pressure

After trying Experiment 7 you will see that the leather holds firmly because there is no air between the piece of leather and the surface on which it sticks and that the pressure on the outside of the leather at (A) Fig. 120, pushes it tightly to the surface. But the way in which the sucker of the octopus sticks is a little harder to understand. In Fig. 119 you will notice that the disk is cup-shaped. The central part (C) is more solid than the lips. The animal presses the suckers against the body of its prey and the central part

* EXPERIMENT No. 7.

Fasten a circular piece of stiff leather about four inches in diameter by a string, Fig. 120. Soak the leather thoroughly in water and then drop it on a very smooth surface. Try to pull it loose by the string and see how tightly it sticks.

is pushed down, filling the cup, it is then drawn back, leaving pressure only on the outside as in the case with the leather disk. When the strong tentacles wrap around an animal and the multitude of suckers get a firm hold, the prey has little chance of escape.

NOTE-BOOK

Draw the octopus at rest.

Tell the ways in which it is like the squid. Unlike it.

What general characteristic divides the two into different orders?

How does it escape its enemies.

Are all devil-fishes large?

What is the use of the tentacles? The suckers?

Explain Experiment No. 7.

How do the suckers act?

THE ARGONAUT

Material needed: If you can, get the shell of the argonaut.

The argonaut (är′gonąut) is also a member of the octopus family. The male is somewhat like the common devil-fish. It is provided with eight arms, but it is only about an inch in length and has neither an internal nor an external shell.

The female, however, is much larger than the male. Two of the eight tentacles are flattened at the end into disk-like sails. These have the important function of secreting the wonderfully beautiful shell in which the female lives and which has made the nautilus so famous.

Because of the delicacy of the shell the argonaut is often

called the "paper nautilus." The shell is spiral in shape and is not divided into rooms or chambers. The animal moves about in this shell but unlike other mollusks that we have studied, is not attached to it.

Stories are told of how the disk-like sails are spread to the breeze, carrying the animal from place to place. But this

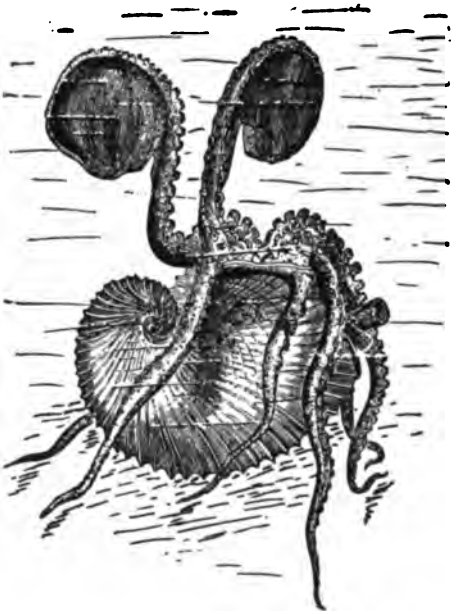


FIG. 121. Argonaut with dorsal arms extended

animal like other higher mollusks swims not by sails but by means of the siphon. In moving the web-like arms are rarely seen as in Fig. 121. They usually grasp the sides of the shell for support.

At egg-laying time the female lives at the surface, carrying her many eggs around in the shell. At other times she lives on the bottom in deep sea.

NOTE-BOOK

Draw the nautilus in its shell.

Compare the male with the female.

What characteristic joins it to the octopus family?

How are two of the tentacles of the female specialized?

What is their double use ?

What are her other tentacles for?

Compare the shell with that of the snail.

What important difference is there in the argonaut's and mussel's way of making the shell?

What is its function?

THE NAUTILUS *

Material needed: The nautilus shell.

One of the most beautiful and wonderful of all shells is that of the pearly nautilus (nạu'ti-lus), some of which are found in Philippine waters. Around the small island of Mactan, to the east of Cebu City, these shells are rather abundant. The nautilus is a very old type. In fact, it is the only living member of the order. As to its habits but little is known. It crawls around over the bottom and probably prefers to live in deep water down below the storms.

When found the shell is cross-striped with faint brick-red bands, but is not polished outside.

Inside of the natural shell can be seen the beautiful play of colors found in all of the pearly nautili (nạu'ti-lī, plural).

* Read *The Chambered Nautilus,* by Oliver Wendell Holmes.

If we were to compare the shell of the nautilus with that of the snail, several points of resemblance would be noticed. Both are coiled up into a spiral; the snail shell like a cork-screw, the nautilus like a clock spring. If we could completely unroll the shell from the large end to the small one, we would have a long cone-shaped tube. This would be quite impossible, however, for the shell has grown hard and fast at each turn. How many whorls do you find? By looking down into the large open end of the shell it will be seen

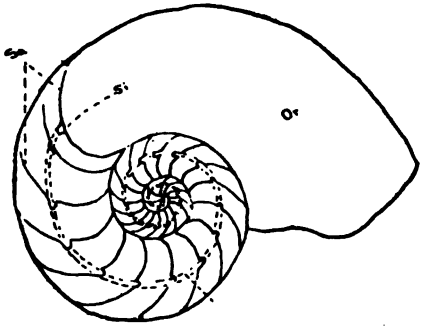


FIG 123. Nautilus cut in two: (Or) outer room; (Sa) septa; (S) siphuncle (Cambridge Natural History)

that the cavity does not extend down very far and that a partition of exquisite color crosses and shuts off an outside room from the rest of the shell. Look carefully to see whether or not this partition contains an opening. In a shell that has been cut through as in Fig. 123 you can see that it is completely divided up into chambers, or rooms, by partitions or septa and that the rooms gradually get smaller from the large outside one to the tiny inner one. Count the number of different rooms, or chambers, that the nautilus has lived in, in its life time. In the mature nautilus there are sometimes as many

as thirty-six chambers. The large outside room was the last one that the animal lived in, and the tiny inside one at the end of the coil, the first. Note that the opening seen in the outer septum is present in every septum, Fig. 123.

The nautilus itself that makes this intricate shell lives in the outside room (Or). From time to time it finds itself too large for its old room and so shifts forward making a new room and closing the old one off by a septum. But the animal remains connected throughout life to all of its old rooms by means of a long tube called the siphuncle (sī'funk-kl), which runs through all of the septa. What other mollusk have we studied that is attached to its shell throughout life?

Some one has compared the living animal to a cauliflower stuck into the nautilus shell. Instead of having disked tentacles, the mouth is surrounded with about ninety lobes bearing tentacles that can be drawn into sheathes at their bases.

In the nautilus the siphon opening from the mantle cavity is not a completely closed tube, as in the squids. The eyes are more simple and the digestive system in general is similar, though more complex. There are four lungs instead of two, and no ink sac is present.

NOTE-BOOK

Draw the shell.

Why is the animal called the "Pearly Nautilus"?

Compare the shell with that of the Argonaut.

How does the Nautilus compare in movement with the mussel; with the devil-fish?

Which is better protected?

Would the septa add strength to the shell?

In what does the shell resemble (and differ from) that of the snail?

How do the numbers of whorls compare in the two?

What is the meaning of the opening in the outside septum?

How do you account for the rooms getting larger from within outward?

Do the lines of growth run in the same or in opposite directions to the brick-red bands?

Compare the nautilus itself with the squid as to kind and number of tentacles.

Enumerate the ways in which the two are different.

SECTION VI

SIMPLE WATER FORMS

THE STARFISH

Material needed: (1) Starfishes to see movement; (2) serpent stars.

The starfish (stär'fish) is shaped like a star, but it is in no sense a fish. It was given the name by people of olden times because of its shape and because it lived in the water. In general all starfishes are alike. There is a central body, containing the vital organs; and from this rays, or arms grow. In some the body is large and the rays are very short and thick; in others, as the serpent stars, Fig. 125, the central part is small and the rays are long and snake-like.

In a walk along the beach at low tide, or in a sail over shallow water, we often see many starfishes. Some are brown or clay-colored, some are red, and others blue. The starfishes of these islands are generally six or eight inches across. In some parts of the world, however, they vary from the size of your finger-nail to three or four feet in diameter.

The starfish is too slow to escape its enemies; it can not defend itself by biting or stinging, so it would be helpless if it had not a strong coat to protect it. As in the crustaceans its coat is made of a lime-like material. But in the starfishes it is made of many little plates. Along the dorsal, or upper part of some of the Philippine starfish are many

strong, sharp-pointed spines that also aid in protection, Fig. 124 (Sp).

There are usually five rays, but sometimes there are eight or more. Occasionally you find a starfish with some of its rays broken off. If left alone they will grow again. At the end of each ray, at (E), you can see a little eye-spot. The

FIG. 124. Starfish: (E) eye; (M) mouth; (Sp) spines (Photograph by Brown)

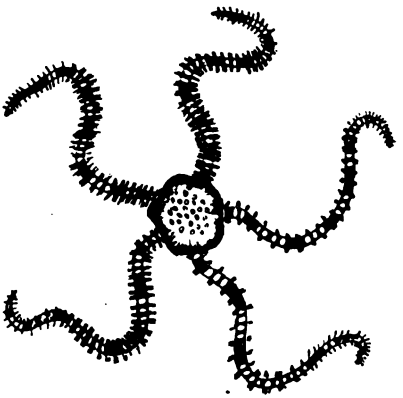


FIG. 125. Serpent star

eyes are sometimes red; sometimes they are transparent. The starfish can not see far with such small eyes but it has no need of better ones. How many eyes has it?

Under each ray is a deep furrow. Each furrow has two double rows of feet. How many rows of feet are there under all the rays? Put a starfish on something flat, and watch it travel. The foot has two parts: (A) the hollow tube, or stalk, and (B) the flat end, or sucker, Fig. 127. In moving, the starfish puts out a ray and takes firm hold with a number of feet, then pulls its body slowly along. It can hold so

firmly with its suckers that it is able to climb up a steep or overhanging surface.

The way in which the foot of the starfish sticks is more difficult to understand than that of the octopus, or devil-fish. At Mp, Fig. 126, is a small porous body, called the madreporic (mäd′re-pōrik) plate. Water enters at this madreporic plate, passes down tube (C), through the circular canal (Cc), and out into the canals of the rays, filling both the canals themselves and the little sacs (Sc) connected with them. If you

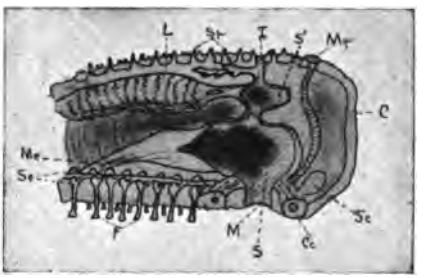


FIG. 126. Ray of starfish: (C) canal; (Cc) circular canal; (I) intestine; (M) mouth; (L) liver; (Me) stomach muscles; (S) first stomach; (S′) second stomach; (Sc) water-sacs; (Sp) spine; (Mp) madreporic plate

should press on one of these little sacs you would find that this would cause the foot to extend. The tubes and the sacs are kept constantly filled with water. When the starfish wants to move it forces water out of these sacs into the feet, thus extending them. When the sucker has touched a flat surface the water is then withdrawn from the foot, leaving no air under it, and the pressure outside of the sucker, see (B) Fig. 127, makes the foot hold fast.

Under the central body of the starfish is the circular

mouth. The mouth leads into a large cavity, the first stomach, Fig. 126 (S). Above this is a second stomach cavity. Extending from the second stomach into the rays are the branches of the liver, which are usually of a greenish color.

The starfish generally lives in shallow water where food is plentiful. It eats such things as snails, oysters, and mus-

FIG. 127. Foot of starfish: (A) tube; (B) disk (After Agassiz)

FIG. 128. Young starfish: (A) beginning of stomach

sels. When the starfish finds an oyster, for example, it arches its body over it, the tube-feet take hold of the shell and by steady pulling the valves open;* the first, or outer stomach then comes out at the mouth and envelops the food, sucking out the soft parts from the shell. The stomach then

* A scientist found that a sudden pull of 4000 grams was needed to open a bivalve shell, while a steady pull of only 900 grams would open it. The starfish was found to be able to pull 1350 grams.

is drawn back into the mouth by the muscle (Me) and the food is digested.

The nervous system is not highly developed. A nerve encircling the mouth gives off branches down each of the rays to the feet and out to the eyes. How are the delicate nerves protected?

Development. The eggs of the starfish are little spherical masses. When laid they soon develop into young that swim freely about by means of cilia.

In the larva, part of the body bends in to form the digestive tract. The larva eats tiny sea animals and grows very slowly. When the rays begin to grow it settles to the bottom and after a long time becomes a grown starfish.

NOTE-BOOK

How did the starfish get its name?

Describe the plan of its body.

Draw the serpent star. Why is it sometimes called the brittle star?

Describe the starfish as to color and size.

Why has it so heavy a skeleton? How does the skeleton differ from that of crustaceans?

For what are the spines used?

Tell about the number and position of the rays.

If a ray is destroyed, what happens?

Where are the eyes? Do you suppose the eye could see if it had no nerve running to it?

How many double rows of feet has the starfish?

Trace the water from the madreporic plate to the feet and explain how the starfish moves.

Describe the digestive organs that branch off from the mouth.

Tell what the starfish eats and how it eats.

How does the young travel?

In what way does the larva change to form its stomach?

Collection: Put a starfish in a glass jar containing 4 per cent. formaline, for the beginning of a permanent collection.

THE SEA-URCHIN

Material needed: (1) Living urchins; (2) spineless shells.

The round, spine-covered body of the urchin (ûr'chin) has little resemblance to the flat, disk-shape of the starfish, yet the two are made in the same general way. The similarity of plan is evident when we study the "sand dollar," one kind of urchin. Although the sand dollar is not provided with rays, yet it is flat and disk-like and looks much like some of the starfishes that have the body very nearly without rays.

The relation to the common starfish may also be seen upon a little study. In both the mouth is under the central part of the body and leads into the stomach cavity; in both the madreporic plate is at the top. Running from the madreporic plate at the top of the shell to the mouth below are furrows that divide the urchin into five sections. If we could take a knife and separate these five sections almost to the mouth, as in Fig. ~~129~~ 130, we could then spread the urchin out into a star-shape and see its close resemblance to the under-

side of the starfish. At the ends of the sections would be the eyes, like the eyes at the ends of the rays of the starfish. Each section would have two double rows of tube-feet which, though longer than the feet of the starfish, would be in the same position, extending from the mouth out to the eye, and having the same general arrangement as in it. How many double rows has each ray of the starfish? *

We have seen that the urchin is covered with sharp spines. The spines are so arranged that they can move in any direction. If you put an urchin on a solid place and let it alone for a moment, you will see the spines begin to move and the long tube-feet come out and take hold of the surface on which it is placed.

The spines are cup-shaped at one end and fit over tiny round points that cover the body, Fig. ~~129~~ 130 (sp). They are held in place by the skin of the urchin. The spines have various uses. They are used for protection, to help in moving, and for burrowing in the solid rock where the urchin may hide itself.

Scattered among the spines are many three-pronged pincers, which are used in keeping the body clean.

* EXPERIMENT No. 8.†

Kill a living urchin by dropping it into hot water for a very short time. Then put it into a glass containing sufficient weak chromic or nitric acid to cover it. Let it remain in this until the shell is soft enough to cut, then with a sharp knife or scissors try cutting it into the plan of the starfish, as suggested, p. 181.

† This experiment should be tried by the teacher, until the strength of the acid and the length of time needed are both satisfactorily understood, before presenting it to the class.

When the urchin dies the spines fall off. Why? We often find the fragile, spineless skeletons scattered along the shore where they have been washed up by the waves.

The mouth of the urchin, like that of the starfish, is round. But in the urchin it has five sharp teeth and is made for biting. When this animal is eating, its teeth do not move up and down, nor sidewise, but they meet at a point. Compare

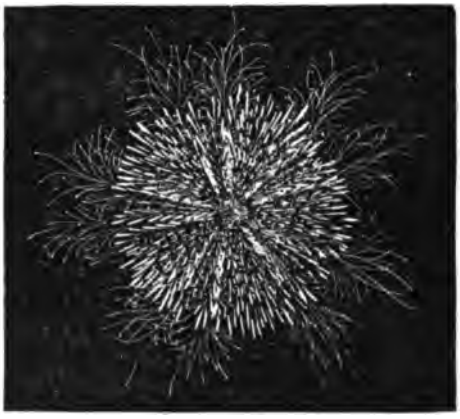


FIG. 129. Sea urchin (After E. and A. Agassiz)

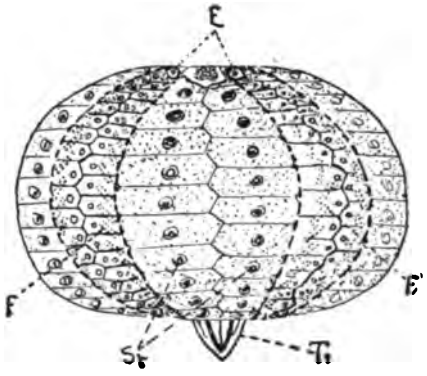


FIG. 130. Urchin without spines: (Tt) teeth; (E) eye; (F) feet; (Sp) points for spines

this with the movement of the grasshopper's jaws. Food goes from the mouth into the stomach and finally into the long intestine where its digestion is completed. The digestive organs of the urchin are more highly developed than in the starfish.

From Fig. 132, compare the water system of the urchin with that of the starfish.

Development. At the top of the urchin (the side opposite

the mouth), around a large central plate there are ten plates; the madreporic plate (Mp), Fig. 133, five smaller eye-plates (E), and four large egg-plates (Ep). Through the holes in

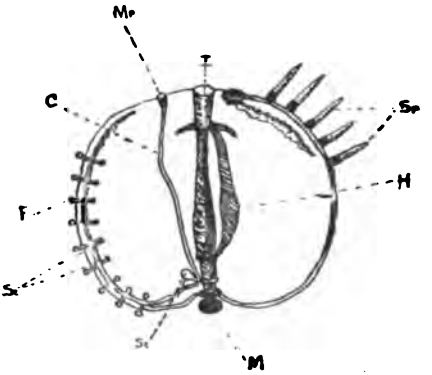


Fig. 132. Diagram of water system in urchin: (C) canal; (F) tube feet; (H) heart; (M) mouth; (I) intestine; (Sc) water sacs; (Sp) spines

Fig. 131. Pincer of urchin

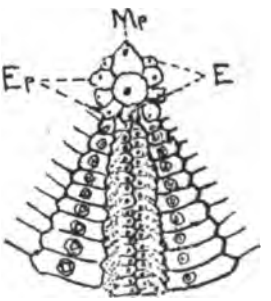


Fig. 133. Top view of urchin: (E) eye; (Ep) egg-plate; (Mp) madreporic plate

the egg-plates the eggs pass out into the water. The young, like that of the starfish, goes through a long and intricate development. It is two or three years in becoming like the parent shape, and ten or twelve years in reaching full size.

NOTE-BOOK

Describe the size and shape of the sea-urchin.

Which does it resemble more closely, the common starfish or the serpent star?

How can we show that the urchin is made like the starfish?

In what ways are the two alike? Unlike?

Describe the feet.

Give the uses of the spines.

Tell about the teeth of the urchin.

Describe its digestion.

Explain the uses of the ten plates that surround the large plate at the top.

JELLYFISH

Material needed: A small jellyfish in a large glass jar to study its movement.

The jellyfish (jĕl'lyfish) is usually disk, or umbrella-shaped. Some jellyfishes are no larger than a pea seed, while others are from one to two meters across. They are of various delicate colors. Sometimes a number of them together will give out a blue light at night which makes the sea glow in beautiful colors. This light is called phosphorescence (fŏs'for-ĕs'çençe).

The umbrella-shaped body has no bone-like skeleton but is made of a transparent, jelly-like material that is largely composed of water. When the body is washed upon the beach the water evaporates from it, and leaves nothing but a few light tubes and tissues.

Around the edge of the body are eight or more (Fig. 134) long arms, called tentacles. The tentacles vary in length according to the size of the jellyfish. In the largest of all they are sometimes more than a hundred feet long. How do they compare in number with the rays of the starfish? The tentacles are armed with lasso-cells (lăs'sō-çells) that are poisonous. The lasso is usually coiled up inside of the cell. (See Fig. 142.) When anything gets tangled up in the ten-

FIG. 134. Jellyfish: (B) margin of disk; (D) disk; (L) lip; (M) mouth; (T) tentacle

tacles, however, they cast out many of these cells and pierce it. Jellyfish used to be called sea-nettles because of the stinging of the lassos. Fish thus caught in the tentacles are soon unable to move and so serve for food.

Between the tentacles, and surrounding the disk are eight simple eyes. In some kinds of jellyfishes the eyes are cov-

ered and invisible, but in others they are visible, Fig. 135.

Extending down from the center of the disk is a tube, a little like the handle of an umbrella. At the bottom of this tube is a large mouth, Fig. 134 (M). Extending down from the mouth are some fluted curtains. These are the lips of the jellyfish (L). The mouth is almost square and is capable of taking food that is very large. The mouth leads up into a large, hollow stomach. How does the position of the mouth compare with that of the starfish?

At the top, the stomach opens into four large tubes. These branch into smaller ones which finally enter a canal that passes all the way around the disk.

Food caught with the tentacles is taken to the mouth. It then passes to the stomach where it is digested. After digestion it goes out through the large tubes into the tiny tubes where it is absorbed by the body walls.

The jellyfish is not fixed to the bottom of the sea, but is free to move where it likes. If you watch one swimming near the top of the water, you can see that the disk has an up-and-down movement. This movement is very regular. You can count about fifteen or twenty pulsations a minute. By these pulsations the jellyfish draws in and forces out water through its mouth. In swimming the handle part of the umbrella extends a little backwards and the water which is forced out at the mouth pushes the jellyfish along. In this way it moves along in search of food. Why do jellyfishes swim in deep water when the sea is rough?

The nervous system is of a very low development. The

cells, however, are connected into a system. There is a circular nerve around the mouth and a branch running off to each eye. There is also a connecting nerve around the margin of the disk.

Development. Few animals have a development as interesting as the life history of some kinds of jellyfishes. The eggs hatch into free-swimmers. Each free-swimmer at this stage is called a planula (plăn′ū-lå). The little planula soon settles to the bottom, becomes plant-shaped, and begins a new

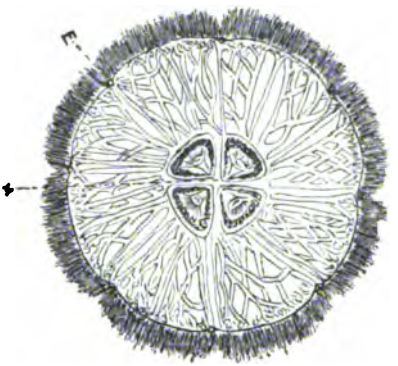


FIG. 135. Looking down upon top of jellyfish: (E) eye; (M) mouth

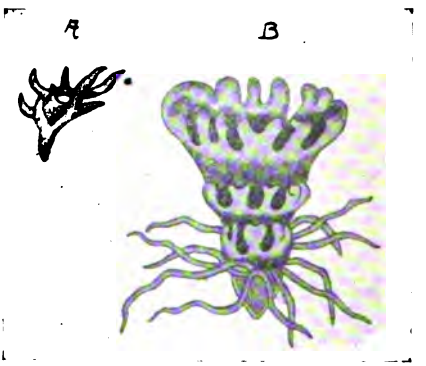


FIG. 136. (A) First stage of hydra; (B) later saucer stage

life. It does not develop into a jellyfish, but into a hydroid (hī′droid), a tiny animal that looks like a plant because of its tentacles. As a hydroid, it leads a fixed life. As it grows larger its body begins to divide into saucer-like sections, Fig. 136 (B). These saucers then break off and float away. They become small jellyfishes that rapidly grow into the large parent forms. The entire life time of even the largest ones is about a year. The eggs are laid in the autumn; in the winter the hydroids grow and develop; when the spring comes the young

jellyfishes are freed from the hydra stock (B); and by autumn they are full-grown jellyfish, which lay their eggs and then die. Thus "the life cycle"—from egg to egg—is completed. In this way there is a continuous change from hydra-like animals to jellyfish, and from jellyfish to hydroids. This is known as "alternation of generations."

A few kinds of jellyfishes develop directly from the egg into the parent forms and never become hydra-like.

NOTE-BOOK

Draw the jellyfish.

Of what is the jellyfish composed?

Tell about its size and shape.

How is the skeleton different from that of higher animals?

Tell about the tentacles and their use.

Describe the eyes.

Give the use of the short, handle-like part under the body.

Describe the digestive tract.

Trace the food in its digestion.

Explain how a jellyfish moves.

Why do we say that the nervous system is of a very low order?

How is the development of the jellyfish peculiar?

Give the four stages in its life history.

What is meant by "life cycle"? Reproduction by alternate generations?

CORALS

Material needed: (1) Living coral, if possible to get; (2) skeletons of different kinds of corals.

Around the Philippine group of islands are many and varied kinds of coral (kor'al). Each kind has its own special form and from this form, or shape, it takes its name. Some, as the branch corals, look not unlike plants or trees. Other kinds are flat and mushroom-like. These are either

FIG. 137. Branch coral

FIG. 138. Mushroom coral

FIG. 139. Brain coral

(Photographs by Brown)

circular, as in Fig. 138, or elliptical, and may grow to be as much as a foot in diameter. The large, round form, known as the brain coral, has its surface roughened into wave-like convolutions (kon'vō lū'tions) much resembling the human brain. (See Fig. 139).

Living coral is of many colors. Sometimes in clear, shallow water, you can look down and see it growing on the bottom. Many kinds grow so close together that they look like a garden of delicately colored plants under the water. Such a group of coral growing together is called a coral grove. A remarkably beautiful grove may be seen near the southern end of Cebu off the little island of Semilum. This grove has an unusual variety of color. In one place may be seen white and green and deep red coral, and in another blue and yellow and pink, while in among them are waving sea-fans and delicately colored sponges.

Although growing coral often looks like plants, yet it belongs to the animal kingdom. Usually each piece of coral is made of a great many tiny animals called polyps (pŏl'yps). Some kinds of polyps are not so large as the point of a pencil, and there are so many together that you could not count them. But others are large. There is one kind that is often a foot or more across.

All polyps do not form coral rock, but in those kinds that are stone forming, the polyps, whether large or small, are much alike. The top part of the body is soft and at the bottom is the hard skeleton.

The soft body of the polyp is shaped somewhat like a cylinder. At the bottom it has a flat base by which it is fastened to the big lime deposit made by the many skeletons together. At the top it looks a little like a flower, Fig. 140. This flower-shape is given by the tentacles that surround the top. There are six or eight or more tentacles for each polyp. The tentacles are hollow and help in catching food.

If we cut a polyp in two in the middle, as in Fig. 141, we can see that it is divided into rooms by fleshy partitions. Note shorter partitions (C) that do not reach to the digestive sac. These partitions are double, and are called septa. Between these double partitions, or septa, at (D) lime-like septa, or walls, arise. This lime-like skeleton first fills up the base of the polyp and rises up between the double fleshy partitions and also fills in the space between the double walls of the body (E). This lime-like formation extends only part way from the bottom to the top of the animal. Could the upper part of the polyp move if the lime extended entirely to

the top? When the polyp dies only the living, or body part, is destroyed. The lime-like skeleton remains and it is this (Figs. 137, 138 and 139) that we usually see.*

As in the jellyfish each tentacle is provided with lasso-cells. Fig. 142 shows the thread-like lasso coiled up inside

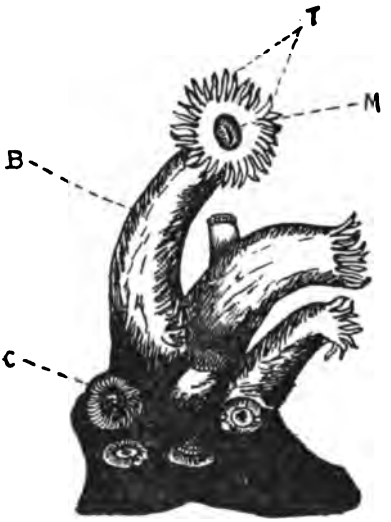


FIG. 140. Group of polyps: (B) body extended; (C) body contracted; (M) mouth; (T) tentacles

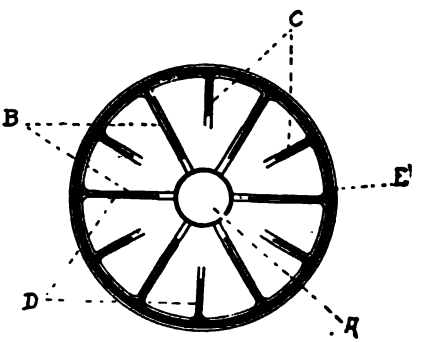


FIG. 141. Diagram of section of polyp: (A) digestive tract; (B) fleshly partitions or septa reaching to stomach; (C) short fleshy septa; (D) lime-like septa inside the fleshy partitions; (E) lime-like deposit between body walls

of the cell. In the polyp the lasso-cell is too small to be seen with the naked eye and the lasso, or thread, is seldom more than an eighth of an inch in length. It seems too small to be of any use, but it is provided with a kind of poison and

* EXPERIMENT No. 9.

Acids destroy lime. To prove that coral is of a lime-like formation put a few pieces of it into a wide-mouthed bottle containing some ten to twenty per cent. nitric acid.

some little darts that stupefy and hold any little animal that is so unfortunate as to be pierced by it. When the lasso-cell is once used it is of no further service, for the lasso can not get back into the cell and so it dies. But another grows as soon as it is destroyed; so the polyp is never left defenseless.

In the center of the upper part of the body, surrounded by

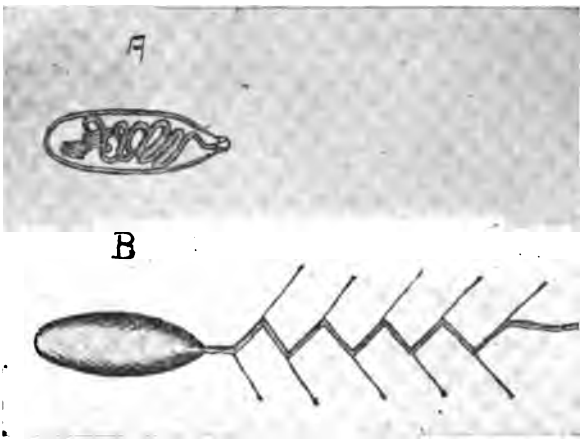


FIG. 142. Lasso-cell: (A) lasso inside; (B) lasso discharged

the tentacles, is the mouth. Fig. 143 (M). The mouth leads into a hollow stomach. The stomach is also lined with lasso-cells and is held in place by the fleshy septa. Notice that each of the six rooms ends at the top in a tentacle, and that all of the septa have holes through them at (O) so that the water can pass from one room to another. Note also that if the polyp is turned upside down that it looks something like a jellyfish.

When the lassos catch food the tentacles force it into the mouth. It is digested in the stomach, then mixed with sea-

water, and passes out at the bottom of the stomach into the six rooms. When the walls have taken up the food, the sea-water passes out through the tentacles.

The polyp has a very simple way of breathing. It has neither lungs nor gills. But when the water touches the walls of its body these are able to absorb the oxygen from it.

The polyp is so low a form of life that we can not say that it has a nervous system. Scattered around over the body are a few nerve cells, but they are not connected into a system.

Development. The coral polyp develops either by buds or by eggs. The egg becomes a young free-swimmer that settles to the bottom. Its tentacles grow and many buds develop from its sides. When it dies it leaves its skeleton and the young continue to bud and to grow from the old skeleton until it is the skeleton of all the polyps that have ever lived in the colony. Sometimes it gets to be ten feet high and fifteen feet around.

Polyps need four general conditions to grow well: First, warm water; second, clear water; third, a current of water; and fourth, water that is not too deep. There are many more polyps in warm, tropical waters than in cold waters. They can not live in the sea near the mouth of a river, because its mud chokes them. They are so low a form that they usually lead a fixed life, and so they need a current of water to bring them food. The polyp is rarely found in water more than a hundred and fifty feet deep, because water deeper than this is too cold for them.

The Work of Coral Polyps. We have seen that polyps in general are small, yet they do work that man could not possi-

bly do. They can make large islands. When coral polyps have favorable conditions they grow very fast. The young build on top of the old coral and after many years the coral reaches the surface in the form of an island. This island is called a coral reef. There are three kinds of coral reefs:

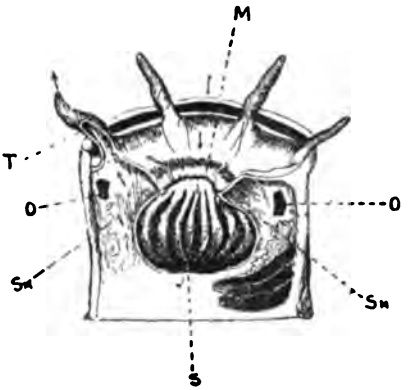


FIG. 143. Body of polyp: (M) mouth; (O) opening between rooms; (S) stomach; (Sm) septa; (T) tentacle

fringing reefs that grow near the shore, barrier reefs that are separated from the shore by deep water, and circular reefs called atolls, Fig. 144. In making an atoll, the polyps probably start to build around the top of a submerged crater, and when the atoll reaches the surface it is in the form of a ring, enclosing a body of water. Why are atolls never high above the surface of the water?

NOTE-BOOK

How do different kinds of coral compare in size and color?

Give a short description of a coral grove.

What is the little animal called that makes coral rock?

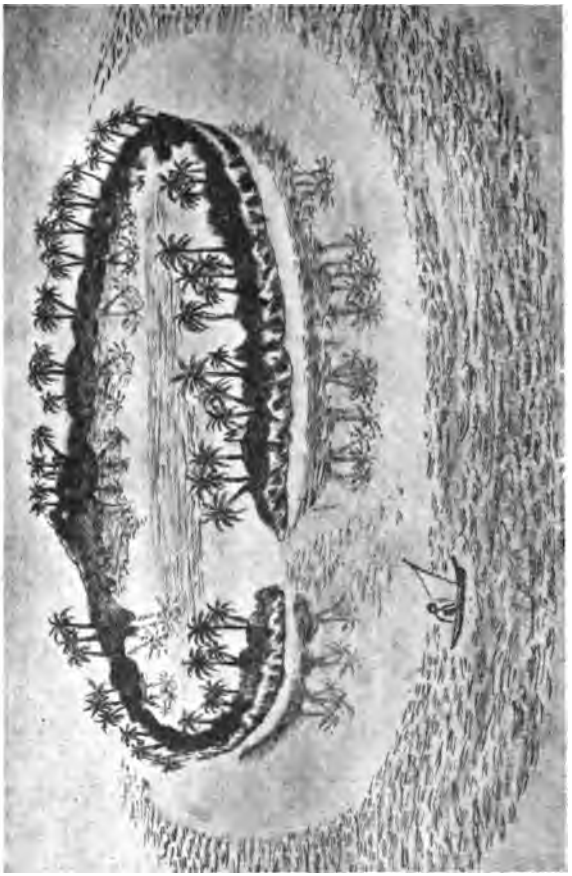


FIG. 144. An atoll

What part of the animal do we usually see?

How does the base differ from the top part?

Describe the body parts; mouth, stomach, the fleshy septa, and the rooms into which the body is divided.

Tell how the skeleton is formed.

For what are the tentacles used?

Describe the lasso-cells and how they are used.

How is the stomach connected with the mouth? With the six rooms of the body? How does this latter compare with that of the jellyfish?

In what is the stomach something like that of the crab?

Tell how the polyp feeds itself.

Explain its breathing.

In what two respects is it a lower form than the jellyfish?

Describe the development of the polyps.

What great work is done by them?

A section across the body of a polyp as in Fig. 141, looks somewhat like a wheel. What part corresponds to the hub, the spokes, the outer rim?

Compare this cross section of the polyp with Fig. 135 of the jellyfish.

SPONGES

Material needed: (1) Living sponges; (2) common sponges; (3) Venus' Flower-Basket.

The Common Sponge. The common sponge (spŭnj) is a very low form of life. Its structure is very simple. It has no head, no eyes, and no feet. For many years sponges were thought to be plants, but now they are known to be animals.

The sponge is made of two general parts: an outer body of

a jelly-like substance, and an inner skeleton. The sponge that we use as a bath sponge is only the skeleton, and not the living part. Its skeleton is made of soft fibers of tough material, called spongin (spŭnjin). When the sponge is living, the skeleton is covered with a jelly-like material. This jelly-like substance looks to be solid, but it is full of pores or openings. In the skeleton, Fig. 145, you may see that these pores are of two kinds; small openings at the sides where the water enters

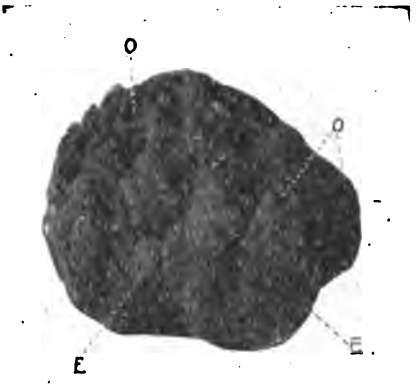


FIG. 145. Common sponge: (E) small openings where water enters; (O) large openings for outgoing water

(E), and one or more large openings at the top where the water goes out (O). Connecting these two kinds of openings are many tubes. If you cut a sponge in two, you will notice that these tubes branch like a tree that is upside down.

Some sponges may be found near the beach in shallow water, while others live in the deep sea. They are usually found where there is plenty of the food that they need.

Sponges lead an inactive life. They can not move around

from place to place, but are fixed to the ocean floor. They are often attached to coral rocks or to shells. The shape and usefulness of the sponge depends largely upon where it grows. If it grows on rough rocks, its base will contain many pieces of rock or grains of sand, so that before we can use it its base must be cut off. If it grows on a smooth bottom, though, where the water is still, it will be regular in shape, and therefore more valuable.

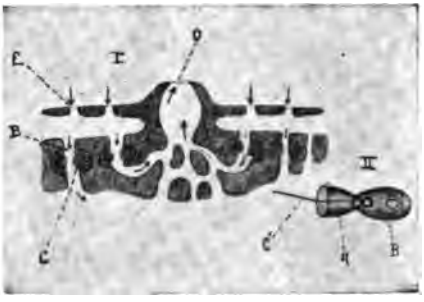


FIG. 146. Diagram of sponge: I. (E) place where water enters; (B) canals; (C) cells that catch food; (O) where water goes out
II. Cell greatly magnified: (B) body; (A) collar; (C') cilium

FIG. 147. Young sponge

Since the sponge can not move around, how does it get its food? It would be difficult to study this from a living sponge. But from Fig. 146 (I), we can see how water enters through small openings (E) in the side of the sponge and passes out at the large openings (O). This water is full of tiny plants and sea animals. But what makes the water enter? There are in the tubes or canals (B) round cavities lined with tiny egg-shaped bodies, or cells (C). Each one of the little bodies has a delicate thread or lash attached to it. Fig. 146 (II)

shows one of them greatly magnified. These bodies are the living cells and the lashes are cilia. The cilia move very fast and drive the water out of the sponge. Then more water enters and keeps passing out, causing a current to flow from E to O through the sponge. The current of water is very necessary, for it brings in food.

When tiny bits of food enter, the little cilia hold them against the cells and the cells absorb the softer parts. The hard part is carried along by the water and passes out at O. The walls of the cells also serve to absorb oxygen from the water and thus are the only organs of respiration.

Life History. Sponges develop in one or two ways; sometimes by budding, but usually by eggs. Some sponges grow in colonies. The colony is formed from little buds that grow out from the parent sponge. Some of these buds break off, float away, and form other sponges, but some stay and so make the colony.

Many more sponges grow from eggs. The eggs are very small and of a yellow color. The egg is a single cell. It passes through the first stages of its development in the body of the parent sponge, then the young, as a rounded mass of cells, leaves the parent. We have learned that the sponge is attached to the bottom of the sea and can not move. The young sponge, however, is a free-swimmer and moves about by means of cilia, Fig. 147. It then settles to the bottom. The lower part of the body bearing the cilia pushes up, forming a sucker-like base. The cilia disappear and the young one becomes attached to the ocean floor.

When many cells have developed, part of them do one

thing and part another. Some of them get the food; others produce eggs or buds. The cells thus become dependent upon one another. Those that catch the food can not produce the new sponges. If no new sponges were produced in a short time the entire sponge class would die out. Those that produce the young can not catch food. And without food,

FIG. 148. Venus' Flower-basket

of course, their life would soon end. In fact, they become so dependent that they could no more get along without one another than could the cells of our hands if the cells of our hearts failed to do their work.

*Venus' Flower-Basket.** The kind of a sponge that we have studied is called a commercial sponge. Why?

Another kind of sponge is the Venus' flower-basket. It is

* The Venus' flower-basket usually may be bought from M. Switzer, Cebu.

used only as an ornament or curiosity. It belongs to the order of glass sponges.

This beautiful sponge makes its home far down in the deep sea, and is found only in Philippine waters. Its outside coat is composed of a jelly-like substance, as in other forms, but the skeleton is made of silicon (sĭl'i kon) instead of spongin. The spicules (spĭk'ūles), or fibers of silicon, forming the skeleton are very white and are like threads of glass. Note that they cross one another regularly and form squares. What do you suppose is the use of these openings along the sides?

The Venus' flower-basket is obtained by divers, or when its body dies the movement of the water may carry it to the beach. Sometimes inside of it is a crab larger than any of the openings. How did it enter? Possibly when the crab was an egg or a tiny thing it was lost from its mother and was carried by the water inside of this sponge. It found this a very pleasant home and was satisfied to stay inside, because the water brought it food. One day, however, when it wanted to get out it found that it had grown too large and that the rest of its days must be spent in prison.

NOTE-BOOK

Give three reasons for saying that the sponge is a very simple form of life.

Name and describe the parts of which a sponge is made.

Compare the skeleton of the sponge with that of the jelly-fish.

What are the small holes along the sides of the sponge used for? The large top opening? What connects these two?

Tell what kind of food the sponge eats and how the food is obtained.

Why does a current of water flow through the sponge? How are the large and small openings in the sponge like the siphons in the mussel?

Describe the different ways a sponge may develop.

How do some of the young differ from the parent?

Why do the cells become so dependent upon one another? Are the cells in man dependent in this way?

Draw the Venus' flower-basket.

Describe its skeleton.

How is this sponge obtained?

Explain how crabs are sometimes found inside of them.

SECTION VII

1. CLASSIFICATION OF ANIMALS

We may now notice briefly how animals, because of peculiar characteristics, are divided into natural groups, or as we say, are classified.

If we take the house cat as a type for classification we would know, that of the three different kingdoms—animal, vegetable and mineral, it is a member of the Animal Kingdom. By possessing a backbone it belongs to the Branch Vertebrata. The cat differs from such animals as birds and reptiles in that its young are nourished by milk secreted by the mother. Thus it is put in the class mammalia. In our study of different types of mammals we learned that forms with teeth of this kind belong to the Order Carnivora. This order is made up of several families which differ from one another in such respects as teeth, claws, etc. The dogs belong to one of these families—the Canidæ, the mongooses to another, the bears to another, and the cats to the Family Felidæ (fēlĭ′dē). Each of these families is further subdivided into smaller groups known as genera—singular gē′nus. Two genera of the family felidæ are distinguished as follows: The genus to which the hunting leopard of southern India belongs is characterized by having claws that

can be drawn back only part way; while the one to which the cat belongs—the genus Felis—has completely retractile claws, that is, claws that are drawn back when the animal is walking. The genus Felis includes many forms, such as the tiger, the lion, the true leopard, the wild cat, as well as the house cat. To separate our type from these the genus is broken up into species. Each of the above, the tiger, lion, etc., represents a species. The house cat from its domestic habits is put into the species Felis domestica.

Just as it is customary for each person to have two names (for example, Ponciano Flores), one the general name of his family (Flores) and the other a special name (Ponciano), given by his parents; so it is in classifying animals. There is a name for the genus—a general name which begins with a capital letter, and a special name for the species usually beginning with a small letter. Thus we speak of the house cat as Felis domestica, the tiger as F. tigris, the lion F. leo—Felis the general name; domestica, tigris and leo the specific names of the three.

From this we see that one or more species (usually more) make a genus; genera form a family; families grouped together give an order; orders compose a class; classes form a branch, or phylum as it is often called; and all of the branches or phyla taken together make up the great kingdom of animals.

In short, we say that the house cat belongs to the branch vertebrata, class mammalia, order Carnivora, family Felidæ, genus Felis, species F. domestica. This is usually written:

Kingdom	Animalia
Branch	Vertebrata
Class	Mammalia
Order	Carnivora
Family	Felidæ
Genus	Felis
Species	Felis domestica.

Name special characteristics which determine that the house cat belongs to the species F. domestica, genus Felis, etc.

2. DISTRIBUTION OF ANIMALS

We have learned that many kinds of animals are found in Malaysia. No other region on the globe, possibly, is so rich in animal life as is this archipelago. There are so many kinds, especially of birds and insects, that it would require years to learn about all of them. So we have confined our study only to those that are typical. On the map of Malaysia (page 211) you will see a line passing between Borneo and the Celebes, and dividing Malaysia into an Eastern and a Western part. It is a curious fact that such a line marks the division of the animal life of Malaysia into two parts also. The animals in the part West of the line are larger and resemble the animals of Asia, while those of Eastern Malaysia are like the more peculiar forms found in Australia.

A study of the ways in which animals are distributed over the earth's surface will help us to understand this division of the fauna of Malaysia better. Unless barred by mountains

animals of all kinds may pass easily from one part of a body of land to another. But how do they cross the sea, and come to inhabit islands?

Some of the smaller forms, like insects, lay their eggs in wood which may float with the eggs or larvæ for hundreds of miles, and may often reach far-away islands.

Reptiles can usually swim, and may be carried long distances on fallen trees.

Birds, like ducks and gulls, can fly far out to sea, so they become widely distributed. Many other kinds, however, will not fly across even a narrow strait. There is a little bird peculiar to the small island of Siquijor that illustrates this. Siquijor is only a few miles from both Cebu and Negros and yet it is the only place where this bird is found.*

It is harder, however, to account for the way in which mammals are distributed. It is not difficult to see how the tiger crosses over from Malacca to Java, for it is a good swimmer. But most monkeys never swim, and yet many of the monkeys of Malaysia doubtless came from Asia, for they are almost identical with some of those now on the mainlaind of Asia. The Malaysian elephants, also, are much like those of India. Indeed they are so nearly alike that they must have sprung from the same ancestors.

Since these larger animals can not have crossed over the water, we must decide that there was a time when they passed freely back and forth on land, from Asia to what is now Malaysia. At that time the mainland of Asia probably ex-

* Circular letter — ornithology. Dean C. Worcester.

tended as far to the south as the Celebes. What is now Sumatra, Java, Bali, Lomboc, Borneo, and the Philippines was once a part of the Asiatic continent.

The breaking off of parts of the continents into islands was caused by volcanic action. You know that the earth's greatest volcanic belt passes through this archipelago. When a volcano throws out a great mass of matter, the country around usually sinks, forming a sea which separates a portion of the land from the mainland.

Borneo, Sumatra, and Java, are separated from the Asiatic mainland by shallow seas, while deep water marks the line of division between Eastern and Western Malaysia. This strengthens the belief that the western part of the archipelago once belonged to the Asiatic continent, and the Eastern part to the Australian continent.

The Philippines, although belonging to Western Malaysia, are peculiar in some respects. They are surrounded by deep seas, so that they seem to have no connection with the mainland. The fauna of the islands, too, differs considerably from that of Asia. The Philippines are rich in insects and in water forms, but they are poor in the larger land animals. There are extremely few large vertebrates, and animals like the tiger and the elephant are wholly wanting.

From the time that an island is separated from the mainland, its animal life begins to differ somewhat from that of the mainland. There is no more passing back and forth and the island forms after many years vary greatly from those of the mainland. Sometimes an island which is thus cut off sinks

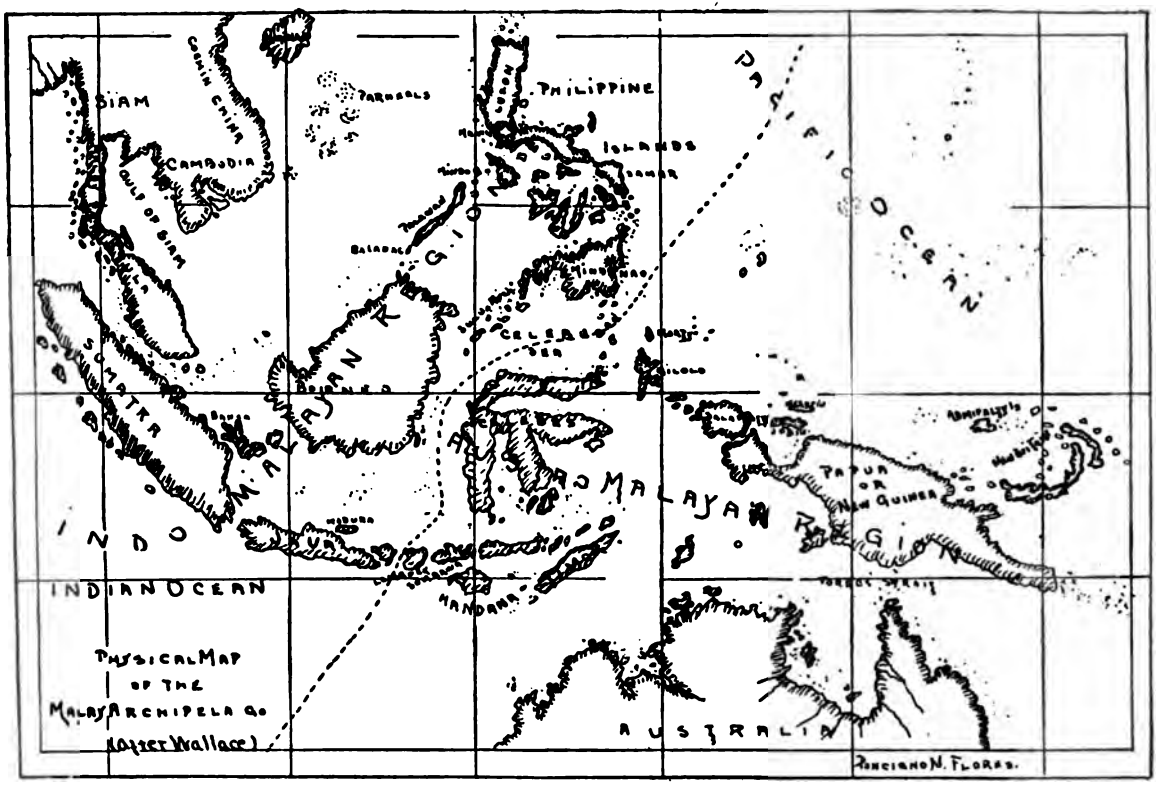
again into the water until only a small part of it is not submerged. In this way nearly all of the large animals are destroyed and only such forms as bats, insects, and small types escape. The Philippines seem to have been thus submerged a long time ago, causing the deep seas that surround them and destroying the larger animals that otherwise would probably be found at the present time in these islands.

THE END

PHYSICAL MAP

OF

MALAY ARCHIPELAGO


SIAM
CAMBODIA
GULF OF SIAM
SUMATRA
INDIAN OCEAN
PHILIPPINE
ISLANDS
CELEBES
PAPUA OR NEW GUINEA
AUSTRALIA
PACIFIC OCEAN
INDO MALAYAN REGION
PHYSICAL MAP OF THE MALAY ARCHIPELAGO (after Wallace)
PANCIANO N. FLORES.

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